MOTOR REPAIR AND OVERHAULING

VOLUME III

BODY, CHASSIS, AND FRAME REPAIRS

Contributors to Volume III

H. W. ALLISON
R. A. BISHOP
A. A. BLAKER, M.I.A.E., A.M.I.M.E.
F. C. BROWN
G. T. CLARKE, F.I.M.T.
H. J. CURTIS
F. G. HAWKINS
A. F. HOULBERG
F. J. HUGHES, M.S.A.E., A.M.INST.T.
W. T. MEAD, M.I.M.T.
DOUGLAS PERCIVAL
J. W. SANDERMAN, A.M.I.A.E.
B. M. SMITH
S. E. SMITH
A. SQUILLARIO
K. SYLVESTER
C. W. G. TAYLOR
B. TURNBULL
D. H. WARREN

GEORGE NEWNES LIMITED
TOWER HOUSE, SOUTHAMPTON STREET, STRAND
LONDON, W.C.2

THE I. T. S. LIBRARY SERVICE
BANGALORE.

A Classified Key and Index to the subject-matter contained in this Volume will be found at the end of Volume IV.

PRINTED IN GREAT BRITAIN BY HAZELL, WATSON & VINEY, LTD., LONDON AND AYLESBURY

CONTENTS OF VOLUME III

PAGE

THE LUVAX HYDRAULIC SHOCK-ABSORBER 1
By Douglas Percival.

REMOVING DENTS FROM WINGS AND PANELS BY HOT-METAL SHRINKAGE 26

SPECIAL POINTS TO BE WATCHED WHEN REPAIRING STANDARD CARS . 39
By B. Turnbull.

SERVICING LANCHESTER CARS 49
Rear Axles, Braking System, Front Suspension, and Steering Gear.
By A. Squillario.

SERVICING VAUXHALL 10-H.P. AND 25-H.P. INDEPENDENT SUSPENSION SYSTEMS 62
By K. Sylvester.

REPAIR AND OVERHAUL OF FORD CARS 71
Rear Axles, Front Axles, Brakes, Steering, and Chassis.
By J. W. Sanderman, A.M.I.A.E.

SERVICING PACKARD SIX, EIGHT, AND SUPER EIGHT, 1937–9 . . 78

REPAIR AND MAINTENANCE OF TILLING-STEVENS CHASSIS . . . 84
Passenger (Type HA39A7) and Goods (Type HA39C4) Models.
By F. J. Hughes, M.S.A.E., A.M.Inst.T.

REPAIR NOTES ON S.S. JAGUAR CARS 93
$1\frac{1}{2}$-, $2\frac{1}{2}$-, $3\frac{1}{2}$-litre.
By D. H. Warren.

HUMBER INDEPENDENT FRONT-WHEEL SUSPENSION 97

SPECIAL POINTS TO BE WATCHED WHEN REPAIRING ALVIS CARS . . 111
By F. C. Brown.

SERVICING CHEVROLET CARS 126
Front-wheel Suspension and Brakes.
By N. A. Moore.

SPECIAL POINTS TO BE WATCHED WHEN REPAIRING GUY COMMERCIAL VEHICLES 143
By R. A. Bishop.

SERVICING COMMER VEHICLES 153
By B. M. Smith.

REPAIR NOTES ON VAUXHALL CARS 169

CELLULOSE REFINISHING FOR THE MOTOR TRADE 185
By H. J. Curtis.

LUVAX BIJUR CHASSIS LUBRICATION 201
By Douglas Percival.

SERVICE AND REPAIR NOTES ON GILFORD "HERA" 32/29 PASSENGER VEHICLES 219
By S. E. Smith.

PAGE

THE REPAIR AND MAINTENANCE OF ALL-STEEL BODIES . . 228
By A. F. Houlberg.

OVERHAUL OF 7-H.P. AND 10-H.P. AUSTIN REAR AXLES . . 277
By W. T. Mead, M.I.M.T.

EXAMINING A CAR FOR ACCIDENTAL DAMAGE AND FRAME REPAIRS . 289
By A. A. Blaker, M.I.A.E., A.M.I.M.E.

HOW TO LOCATE AND REMEDY CAR NOISES 319
By C. W. G. Taylor.

DENNIS 35-, 40-, 50-, AND 60-CWT. GOODS-CARRYING VEHICLE . . 325

HILLMAN MINX 341

REPAIR NOTES ON THE FIAT MODEL-500 CAR 353

LEYLAND VEHICLES 369

THE MORGAN 4/4 CAR 398

THE SCAMMELL MECHANICAL HORSE 403

REMOVING BODIES FOR FRAME REPAIRS 414

THE MORRIS EIGHT CHASSIS AND BODY (SERIES E) 422

ROVER REAR AXLES 432
By F. G. Hawkins.

THE TRIUMPH CHASSIS AND BODY 440
By H. W. Allison.

THE A.E.C. CHASSIS 449

ROAD SPRINGS AND SPRING BUSHES 467
By George T. Clarke, F.I.M.T.

VEHICLE BRAKE TESTING 487

THE BEDFORD CHASSIS 495

ADAPTING EXISTING BODYWORK FOR EMERGENCY USE . . . 511
By H. J. Butler.

ANDRE HYDRO-TELECONTROL SHOCK-ABSORBER SYSTEM . . . 528
By George T. Clarke.

THE MORRIS TEN CHASSIS (SERIES M) 538

RADIATOR REPAIRS 545

STRAIGHTENING, CHECKING, AND ALIGNING FRONT AXLES . . . 557

THE VAUXHALL FOURTEEN (MODEL "J") 567
With further Notes on the Ten and Twelve.

THE DAIMLER STRAIGHT EIGHT (3½-LITRE) 576
By A. Squillario.

THE THORNYCROFT STURDY CHASSIS 580
Chassis Type ZE 5-ton (Forward Control). YE 5-ton (Normal Control).

THE LUVAX HYDRAULIC SHOCK-ABSORBER

By DOUGLAS PERCIVAL

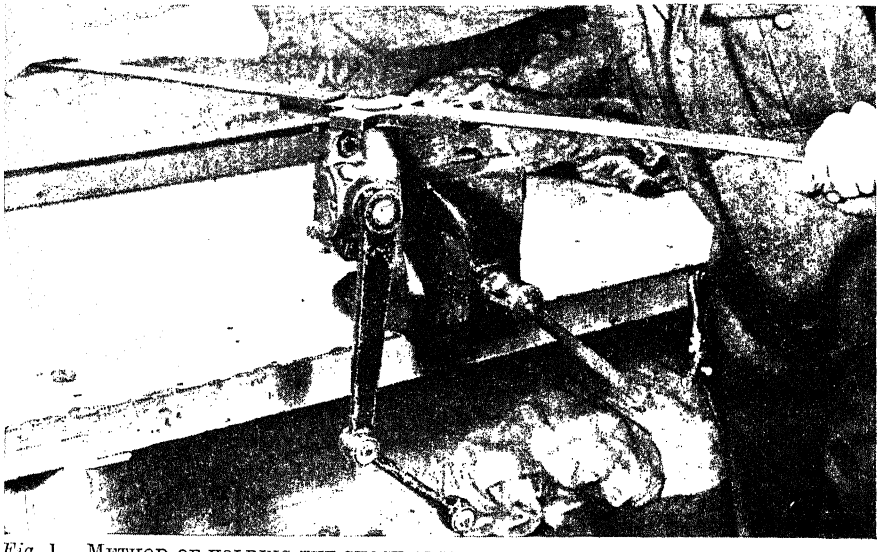


Fig. 1.—METHOD OF HOLDING THE SHOCK-ABSORBER IN A VICE FOR TIGHTENING END CAPS

ON present-day cars the hydraulic shock-absorbers form a very important part of the suspension system. Before dealing with their construction and maintenance, we will consider their function, as it is most necessary that this is clearly understood.

Why Shock-absorbers are Fitted

Shock-absorbers are fitted in an endeavour to provide a means of absorbing and dissipating the forces produced by the wheels travelling over irregular surfaces, which tend to impart vertical movement to the body. The springs, which form resilient members between the wheels and body, are intended to deflect or compress and thus absorb the "shocks" or disturbing forces. The primary function of the shock-absorbers is to dissipate these forces when thrown off by the springs in the form of "rebound."

It will, therefore, be seen that the duty performed by the shock-absorbers is not that which is implied by their name. This is responsible for causing a great deal of misunderstanding. A more descriptive name would be " spring dampers " or " oscillation retarders."

Let us analyse the motion of a car travelling over a rough road under the following conditions :

(1) Without springs or shock-absorbers.
(2) With springs but without shock-absorbers.
(3) With springs and hydraulic shock-absorbers.

What happens when a Car is without Springs or Shock-absorbers

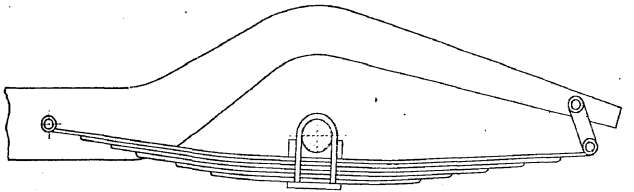
If a car is without springs, the shock occasioned by the wheels encountering bumps and depressions in the road would be transmitted direct to the chassis frame and body. All these would be thrown upwards and downwards in one mass, and the vertical accelerations and decelerations would be of a high order, dependent upon the force of impact between wheels and road—the result being acute discomfort to the passengers.

Car with Springs but without Shock-absorbers

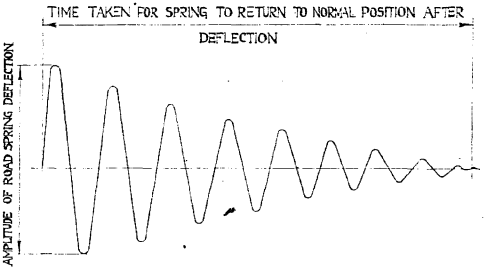
In order to obtain better results than in the above case, all cars are fitted with some form of spring interposed between the wheels and body—the conditions then being that the wheels can move vertically in relation to the body. When the wheels receive impact from road irregularities, they are forced towards the body, and the force or energy or shock, instead of being transmitted direct to the body is absorbed by the springs, which are compressed in the process. It should be noted that the energy is absorbed in the compressed springs, but not dissipated. In all springs the energy absorbed under these conditions must be thrown out again. The output of energy is responsible for what we term the " rebound," and this forces the wheels and body apart again. Subsequent to the rebound from the initial compression, the springs will continue to go up and down a number of times ; these motions, or oscillations, we shall later refer to as " persistence." It will be appreciated that the conditions are better in this case than in the previous case, as the road shocks are absorbed by the springs, although there is the disadvantage of an uncontrolled rebound and subsequent oscillations which would produce what is commonly called " body bounce."

Conditions when a Car has both Springs and Shock-absorbers

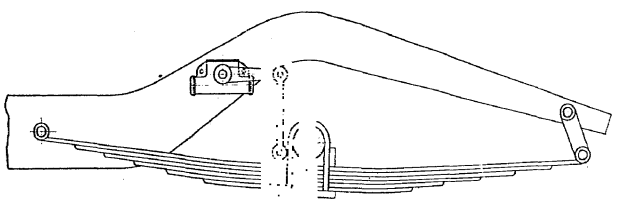
The final example is a car with road springs and hydraulic shock-absorbers. As in the previous case, the impact of the wheels against road irregularities produces a force which is absorbed by the springs, but in this case the resultant output of energy in the form of " rebound " and " persistence " is dissipated or damped by the hydraulic shock-absorber.



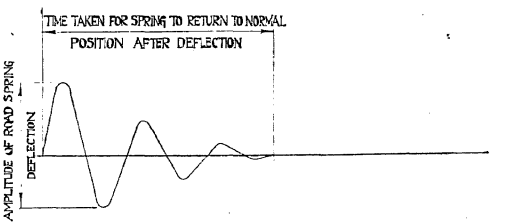
SPRING SUSPENSION SYSTEM ON REAR OF CHASSIS WITHOUT SHOCK ABSORBER



DIAGRAMMATIC OSCILLATION CURVE OF ROAD SPRING WITHOUT SHOCK ABSORBER



SPRING SUSPENSION SYSTEM ON REAR OF CHASSIS WITH SHOCK ABSORBER



DIAGRAMMATIC OSCILLATION CURVE OF ROAD SPRING WITH SHOCK ABSORBER

Fig. 2.—DIAGRAMMATIC OSCILLATION-CURVE OF A SPRING WITH AND WITHOUT SHOCK-ABSORBERS

In other words, the surplus energy in the spring is expended in forcing a volume of fluid through a small hole or valve in the shock-absorber, instead of by oscillating the body upwards and downwards. By this means a controlled "ride" is obtained, the springs flexing to absorb impacts and the hydraulic shock-absorber controlling the subsequent rebound.

The Ideal Road Spring and What has been attained in Practice

The above three examples touch only on the elements of the theory of suspension, and are intended to serve as an illustration only.

In actual practice there are many other considerations involved; for instance, the pneumatic tyres form a cushion between the wheels and road, and therefore play a part in the suspension system. Also, although the road springs are intended to absorb the shocks, in practice they only partly succeed, as no form of road spring has yet been found capable of absorbing *all* road irregularities without imparting some vertical movement to the body.

The perfect spring would deflect instantaneously the amount necessary to enable the wheels to follow the road contour, without disturbing the body, but this ideal has not yet been attained.

The Damping Effect of Shock-absorbers

Yet again, it is not found desirable to damp or retard the springs by the shock-absorbers to such an extent that they return from the compressed position to normal in one movement without subsequent oscillations. If this were done the rate of deceleration would be too high and would produce the effect of a harsh ride. The object at which to aim is to bring the springs to rest *smoothly* in the minimum time. This is illustrated in Fig. 2, which shows a diagrammatic oscillation curve of a spring with and without shock-absorbers. The amount of damping necessary to achieve the best results requires very careful consideration. It is not the same for a given size of car, that is to say, one make of 10-h.p. car may require quite a different type and amount of damping to a similar-h.p. car of a different design. One may require double-acting shock-absorbers and the other single, one high-resistance and the other low. This is because the damping required is dependent upon the characteristics of the road springs, weight distribution, and other factors, each of which may vary widely.

Importance of fitting the Correct Shock-absorber

The subject is an extremely complicated one, and, therefore, before a car manufacturer commences production of a new model there is usually a large amount of intensive research and experimental work carried out by the combined technical resources of the motor-car company and the shock-absorber manufacturers, in order to arrive at the most suitable

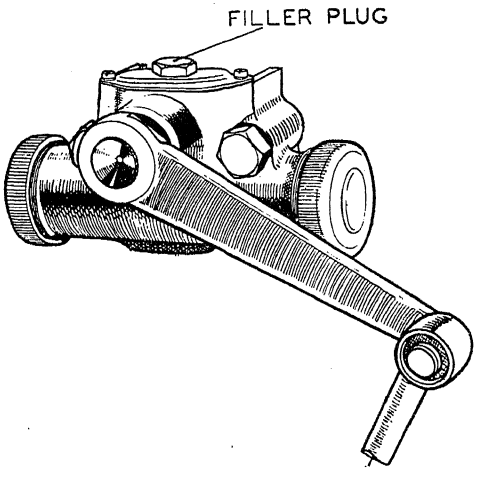


Fig. 2A.—LUVAX PISTON-TYPE SHOCK-ABSORBER

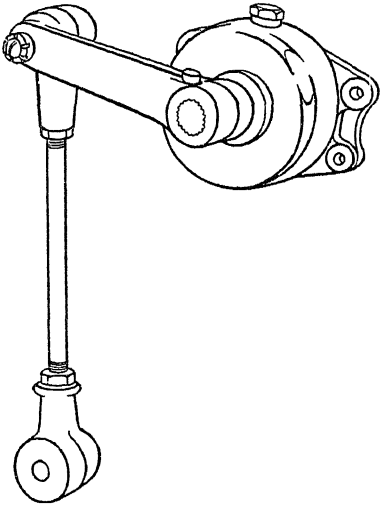


Fig. 2B.—LUVAX VANE-TYPE SHOCK-ABSORBER

shock-absorber characteristics for that particular model. It is, then, most important that the manufacturers' adjustment is not varied unless special conditions are to be catered for; also, when removing a shock-absorber from a car for replacement, care should be taken that the new unit has the same characteristics as that originally fitted.

Hydraulic and Dry-friction Shock-absorbers Compared

At this stage it may be of interest to consider why the hydraulic shock-absorber has been so universally adopted, to the almost total exclusion of the dry-friction type. The principal reason is because fluid friction increases with speed ; this means that when the axle moves fast due to a big impact with the road, the hydraulic shock-absorber resistance automatically builds up to its maximum. With slow-speed axle movement the resistance offered by the shock-absorber is proportionately less—thus an automatic control is obtained. With dry-friction type the automatic " build up " with speed is absent, as dry friction is irrespective of speed.

CONSTRUCTION OF LUVAX HYDRAULIC SHOCK-ABSORBERS

The Luvax shock-absorbers are made in several different sizes and types, but may be divided into two main groups, the piston types and the vane types. They are both hydraulic and their function is the same, but their design and method of operation differ widely one from the other.

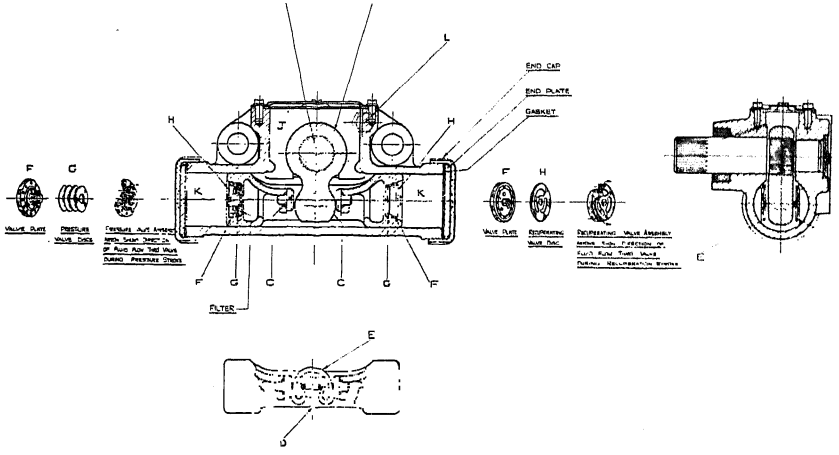


Fig. 3.—CONSTRUCTION OF THE DOUBLE-ACTING AND DIFFERENTIAL-ACTING PISTON TYPES

Piston Types of Shock-absorber

The piston type may be either double-acting, which gives equal resistance in both directions; differential-acting, which offers more resistance to the recoil of the road spring than the compression; or single-acting, which offers resistance to the recoil of the road spring only, being free in the other direction.

The double-acting and differential-acting types are of the same construction. The different effect is obtained by arranging the internal valves as required, this being done during their manufacture. They are of the horizontal-cylinder twin-piston type, and are normally mounted on the chassis frame and connected by means of a lever arm and link to the axle. On some cars it has been found more convenient to mount them on the axle and to connect by the arm and link to the frame, but there are only a few instances of this being done. Fig. 6 shows a typical layout with the shock-absorber mounted on the frame.

The single-acting type has only one piston, and is usually mounted with the cylinder vertical. It is normally mounted on the frame, but may be mounted on the axle if necessary. The axle movement is transmitted by a similar arm and link to that used with the double-acting type.

The Double-acting and Differential-acting Types

The construction of the double- and differential-acting types is illustrated in Fig. 3, and the description is as follows:

Mounted on the rocker shaft *A* on tightly fitting serrations, the rocker *B* converts the rotary motion of the shaft to the reciprocating motion of the pistons through the hardened surfaces *CC*. The pistons are co-axial, but separated by the division *D*; the springs *EE* flexibly join the two

pistons. Any wear on the faces *C C* is thus taken up automatically. It will be seen that the thrust from the rocker is taken direct on the piston, without passing it through the springs.

In the outer ends of the pistons a circular valve plate *F* is fitted. This carries on its inner seating the pressure valve *G*, which is arranged to open when the predetermined pressure is reached. On the outer seating of the plate *F*, a recuperator valve *H* permits the fluid to flow freely from the recuperator chamber *J* to the pressure chamber *K*. There is also a small orifice in the outer end of the piston which allows a small flow of fluid to pass from the high-pressure chambers to the recuperator chamber. This is referred to as the " bleed," and it controls the resistance at speeds lower than that which is required to open the pressure valve *G*.

The filler plug *L* is positioned to give the correct fluid-level. This is obtained by pouring in fluid until it overflows.

The operation on the car is as follows :

When the body and axle are forced towards each other (road springs compressing), motion is transmitted by the connecting link and lever arm to the rocker shaft, which rotates and causes lateral movement of the pistons, let us say, to the left. At the commencement of the stroke resistance is offered dependent on the pressure required to force the fluid in the left-hand pressure chamber, through the bleed in the piston, to the recuperator chamber. As the axle speed (and therefore piston speed) increases, the pressure or resistance builds up according to the hydraulic law, the limit being reached when the pressure valve *G* opens. During this stroke the recuperator valve *H* in the right-hand piston opens and allows free flow of fluid from the recuperator chamber to the pressure chamber, thus ensuring that it is kept completely full of fluid. Movement to the right follows the same cycle.

The " bleed " and the tension of the pressure valves *G* are accurately calibrated during manufacture, so as to be of the correct value for the car to which they are to be fitted. No further adjustment is required or provided for.

In the double-acting type, the bleed and pressure-valve values are the same in both pistons ; in the differential-acting type the bleed and/or pressure-valve values are lower on the side which takes the compression of the road spring than on the recoil side.

The lever arm is a force-fit on the shaft serrations, and the end of the shaft is " staked " in three places to retain the lever longitudinally. The connecting link is bushed with special torsion rubbers which form silent, oil-less, flexible bearings.

Single-acting Piston Type of Shock-absorber

Fig. 4 shows the construction of the single-acting type, which is described below :

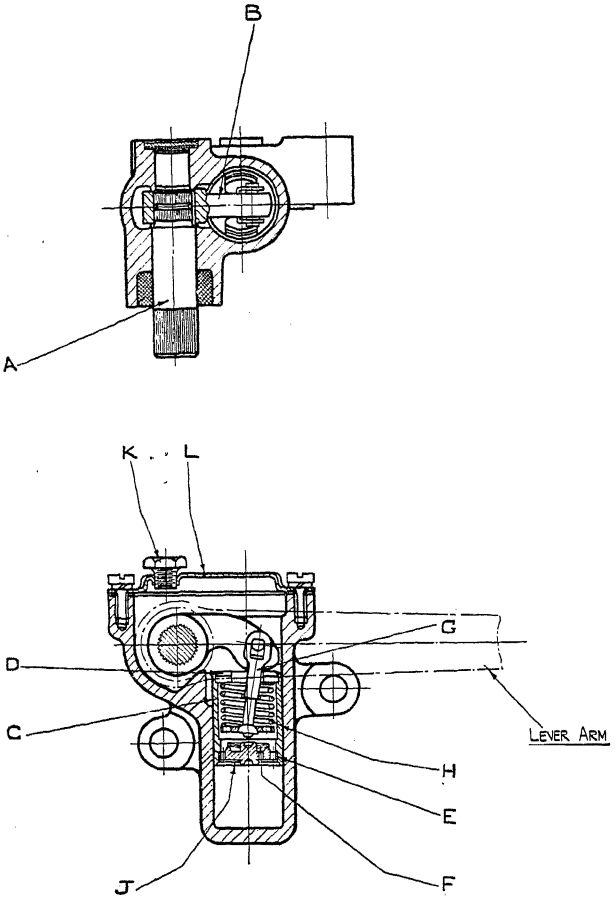


Fig. 4.—CONSTRUCTION OF THE SINGLE-ACTING PISTON TYPE

When the lever arm moves downwards, the rocker *B*, which is mounted on the shaft *A* on tightly fitting serrations, forces the piston *C* downwards by pressure on the hardened surface *D*. In the lower end of the piston a circular valve-plate *E* is fitted. This carries on its inner seating the pressure valve *F*, which is arranged to open when the predetermined pressure is reached. This permits fluid to pass from the under side of the piston, which is the pressure side, to the upper side, which is the low-pressure or recuperator-chamber side. There is also a small orifice in the end of the piston which permits a small flow of fluid to pass from the high- to the low-pressure side. This is referred to as the "bleed," and it controls the resistance at speeds lower than that which is required to open the pressure valve *F*. The piston is flexibly connected to the rocker arm by means of the coupling yoke *G* and the compression spring *H*. The pressure exerted by spring *H* holds the rocker in close engagement with the piston under all conditions, and automatically takes up any wear which may occur on the rocker or piston face. When the lever arm moves upwards the piston is drawn upwards in the cylinder by the rocker and coupling yoke. During this stroke fluid is permitted to pass freely from the upper side of the piston to the lower by the lightly loaded recuperator valve *J*. The pressure

chamber is thus kept solidly full of fluid in readiness for the next pressure stroke.

The filler plug *K* is positioned in the top cover *L*. The correct fluid-level is obtained by pouring in fluid until it overflows.

The operation on the car is as follows :

When the body and axle are forced towards each other (road springs compressing), motion is transmitted by the connecting link and lever arm to the rocker shaft, which rotates. The piston is drawn upwards in the cylinder, and as the fluid may pass freely through the recuperator valve *J* there is no resistance. The transfer of fluid through valve *J* ensures that the pressure chamber is always solidly full of fluid. When the body and axle move away from each other (road spring extending or rebounding), the piston is forced downwards in the cylinder. At the commencement of this stroke resistance is offered dependent on the pressure required to force the fluid below the piston through the " bleed " to the low-pressure side. As the axle speed increases, the pressure or resistance builds up, the limit being reached when the pressure valve *F* opens. The " bleed " and tension of the pressure valve *F* are accurately calibrated during manufacture so as to be of the correct value for the car to which they are to be fitted. No further adjustment is required or provided for.

Vane-type Shock-absorber

The Luvax vane-type shock-absorber is shown in Fig. 5. The construction and operation are simple, so that only the following brief description is necessary.

They may be either single-acting, differential-acting, or double-acting, the different effect being obtained by the arrangement of the internal valves. The principal components are the working chamber *A*, the reacting block *B*, the rotor *C*, the recuperator chamber *D*, and the bottom cover *E*. The shock-absorber is normally mounted on the frame, with the rotor shaft connected to the axle by a similar type of lever arm and link to that used with the piston type. The filler plug *F* is situated on the top of the recuperator chamber, and the correct fluid-level is $\frac{3}{4}$ in. from the top. The working chamber should always be completely full.

The operation of the double-acting type is as follows :

As the car spring compresses, the lever arm moves and rotates the rotor, let us say to the right. The rotor vane forces the fluid in front of it through the transfer hole *G* in the reacting block to the other side. The flow of fluid through the transfer hole *G* is partially obstructed by the adjusting screw *H*. Thus resistance is offered to the lever-arm movement, dependent upon the pressure required to force the fluid past the adjusting screw. The rebound of the car spring causes the rotor to rotate in the opposite direction, the vane of the rotor again forcing the fluid through the partially obstructed transfer hole *G*. The resistance

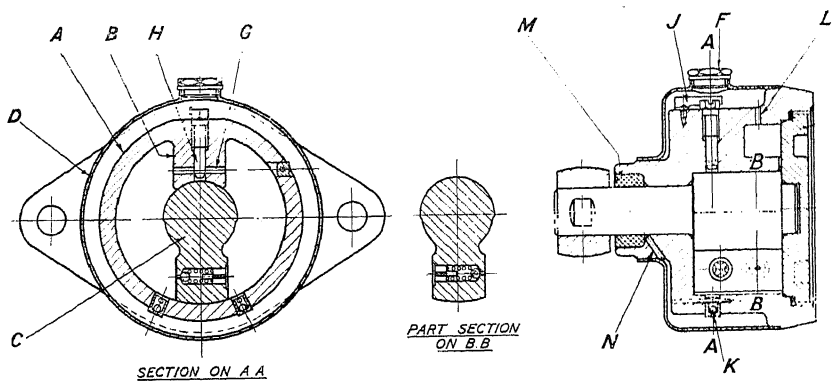


Fig. 5.—CONSTRUCTION OF THE VANE TYPE

offered is the same in both directions. It will be readily seen that screwing the adjusting screw upwards or downwards decreases or increases the resistance. The adjusting screw is screwed with a fine thread and has a tapered point, so that a very fine adjustment can be obtained. The locking spring *J* locks the adjusting screw every one-sixth turn.

To safeguard against any possible loss of fluid in the working chamber, a means of automatic recuperation is provided by the recuperator chamber *D*, which carries a large supply of reserve fluid, which is drawn through the recuperator valves *K* into the working chamber when required, the air being discharged through the air-release duct *L*. The gland *M* prevents any escape of fluid along the rotor shaft, and the duct *N* allows any excess to return to the recuperator chamber.

The differential- and single-acting types operate in the same manner as above, with the exception that a spring-loaded by-pass valve is incorporated in the reacting block to give an additional path for the fluid on the compression stroke of the car spring. This valve is arranged, during manufacture, to offer the required resistance for differential action or to permit a free flow for single action.

The construction of the by-pass valve varies in different models ; it may be either a ball valve or a sleeve valve, but the principle of operation is the same. In some instances a spring-loaded valve is incorporated for both the compression and rebound strokes, to limit the resistance building up beyond a predetermined figure.

MAINTENANCE AND SERVICE REPAIRS

Maintenance of Piston Types

Occasionally a check should be made to ascertain if they require replenishing with fluid. This is done by checking the resistance, which, if uniform throughout the complete stroke of the lever arm, indicates that

the fluid-level is adequate. The resistance of each shock-absorber may be quickly checked by bouncing each corner of the car up and down and observing the movement. If there is any doubt that the springs are adequately controlled, a more positive check should be made by disconnecting the shock-absorber connecting links and moving the lever arms by hand. If the resistance in any one shock-absorber does not feel uniform, but appears to be erratic with free movement during part of the stroke, the shock-absorber should be removed from the car for topping up with fluid.

It is recommended that the units are removed from the car for topping up, as it is vitally important that no dirt or foreign matter enters. When a shock-absorber has been removed, it should be wiped clean before the filler plug is taken out. Fluid may then be poured in until it overflows from the plug hole. Whilst this is being done the lever arm should be worked up and down through its full stroke to expel air from the pressure chamber.

In all the piston-type units, it is most important that only Luvax Piston Type Thin Fluid is used. This is a special fluid, the properties of which have been carefully selected to comply with the conditions essential for the efficient working of the shock-absorber.

Service Repairs of Luvax Piston Types

If a repair becomes necessary owing to trouble developing, such as loss of resistance or fluid leakage, etc., it is advisable under normal circumstances, unless the required repair is of a very minor nature, to return the complete unit to the manufacturers for rectification or replacement. Special tools and plant are required for carrying out repairs efficiently and economically, and the installation in garages or service stations of the complete equipment would not be justified by the relatively small number of repairs handled. Instances may be met with, however, where obtaining a manufacturer's repair or replacement may involve a delay which would inconvenience the customer. To meet such circumstances we will describe a number of repairs which can be carried out satisfactorily in the garage with the aid of a few special service tools and spare parts, which may be obtained from the manufacturers.

Troubles and Remedies—Horizontal Double-piston Type

Here are some troubles which may possibly occur with the horizontal double-piston type, with instructions for carrying out a service repair should it be found necessary.

Fluid Leakage from High-pressure Joints

There are only two high-pressure joints, namely the two screwed-on end caps, one at either end of the cylinder. If leakage occurs at one of these it will probably be caused by the cap not being sufficiently tight.

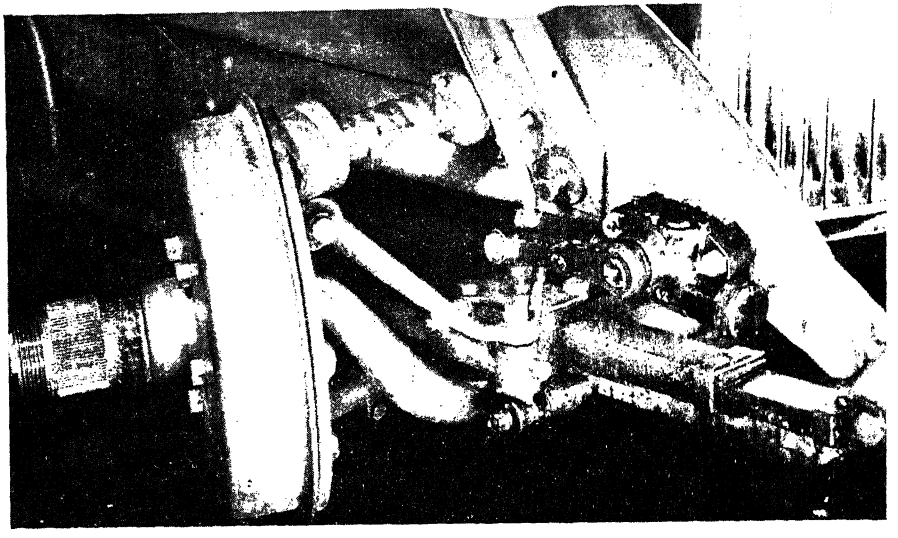


Fig. 6.—TYPICAL MOUNTING ON FRONT OF CAR OF A LUVAX HORIZONTAL PISTON-TYPE SHOCK-ABSORBER

They must be properly tightened up, and this should be done with the special spanner supplied by the makers. This is such that it gives a perfectly even grip around the cap and so avoids distortion. If the cap is distorted during tightening, a fluid-tight joint will not be made. In order to hold the shock-absorber firmly in the vice without damaging the casting, or distorting the cylinder, it should be bolted to a piece of flat steel plate approximately ½ in. thick and the plate clamped in the vice as shown in Fig. 1. There are four sizes of Luvax piston-type shock-absorbers, and it is well worth while drilling a plate with four sets of holes so that it is suitable for any size.

Fluid Leakage from Shaft End Washer

Another possible leakage point is from the shaft end washer. This is a well-known type of sealing washer. It is a domed steel washer which, when assembled, is flattened out, thus forcing the outer edge into a groove in the casting. If leakage occurs, pressure applied to the centre of the washer will tighten the joint. This job may be readily accomplished in a vice by holding a short piece of round steel bar against the domed washer and clamping the end of the bar and the end of the shaft between the jaws of the vice, as shown in Fig. 7.

Leakage at Top Cover

A leakage at the top cover may usually be rectified by tightening the cover-retaining screws. If, however, this does not have the desired effect,

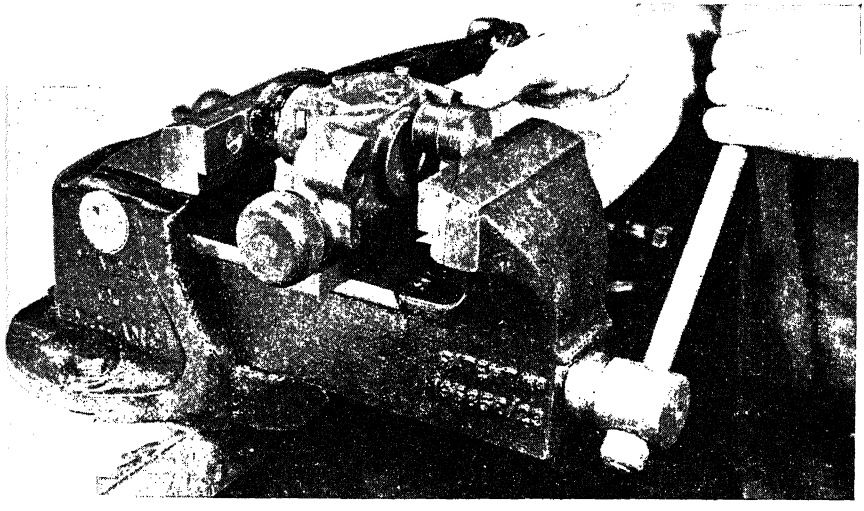


Fig. 7.—METHOD OF TIGHTENING THE SHAFT END WASHER IN A VICE

it may be that a new gasket is required or the cover has become distorted. Spares may be obtained from the makers. We would emphasise the importance of obtaining spare parts only from the makers of the shock-absorbers, in order to ensure interchangeability and reliability. A jointing compound such as Hermetite is used to assist in making the joint. Before fitting a new gasket or cover or refitting the old one, the original jointing compound should be carefully scraped away from both these parts and also from the top of the casting, care being taken to avoid any particles falling inside. We again make special mention of the vital importance of ensuring that no particles of dirt or foreign matter enter the shock-absorber. If small pieces of solid matter are trapped under the valves, it will prevent their closing properly and resistance will be lost. Care should also be used when assembling to prevent excess compound being used and squeezed into the shock-absorber. Tighten each retaining screw a little in turn so as to pull down the cover evenly and avoid distortion.

The Gland

The gland is of such a construction that it cannot leak, and it needs no attention throughout the entire life of the shock-absorber.

Remedying Loss of Resistance

If the resistance is found to be weak or erratic and cannot be restored by topping up with fluid and expelling the air by working the lever arm up and down, as described under "Maintenance," an examination of the unit should be carried out.

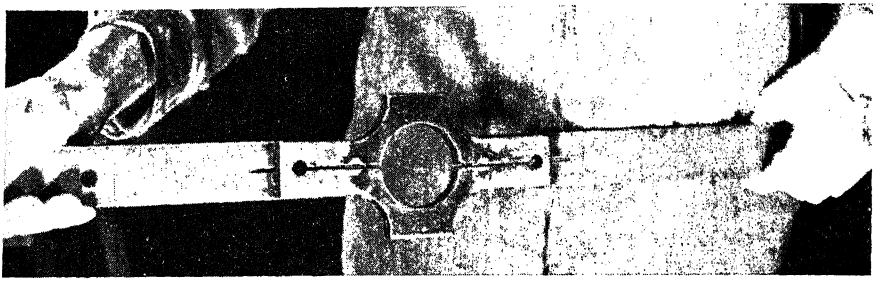


Fig. 8.—END-CAP SPANNER FOR PISTON TYPE

Loss of resistance in one or both directions may be caused in several ways; it may be due to fractured internal parts, such as the shaft or rocker arm or piston coupling linkage. In such cases the shock-absorber should be returned to the manufacturers for repair, as a complete dismantle is involved, but it is very seldom that any of these failures occur. A more likely cause of lost resistance is a faulty valve. This may be due to dirt or foreign matter under the valve discs preventing them from seating correctly, or to a mechanical failure of the valve parts. A faulty valve or valves in one piston only will affect the resistance in one direction only, i.e. when that piston is moving through its pressure stroke. If the valves in both pistons are faulty, then the resistance will be affected in both directions. This trouble may be rectified as follows:

Rectifying Faulty Valves

Mount the shock-absorber on the clamp plate and tighten up in a vice as shown in Fig. 1. If the resistance is affected in one direction only, mount the shock-absorber so that the affected piston is uppermost. If it is weak in both directions, each end must be treated in turn. Using the special end-cap spanner (Fig. 8), unscrew and remove the end-cap, end-plate, and gasket. Move the lever arm so that the piston is brought to the end of the cylinder. In most of these units the valve-plate (which carries the pressure and recuperator valves) is retained in the end of the piston by a spring clip. This enables the complete valve-plate, with valves, to be readily removed.

Units with Spring-retained Valve-plates

The following instructions appertain to units with spring-retained valve-plates. There is a small hole in the centre of the valve-plate, tapped with a 5BA thread into which a screw may be inserted. A straight pull on the screw by hand will withdraw the plate from the piston. Mention must be made here that the "bleed" hole in the piston is fitted with a small, accurately sized meter-pin, which controls the fluid

flow. This pin is a little less than $\frac{1}{16}$ in. diameter by approximately $\frac{1}{4}$ in. long. It is held in position by the valve-plate, consequently when the plate is withdrawn the meter-pin may fall out. It should therefore be removed and carefully kept on one side, so that it may be reinserted in the " bleed " hole before the valve-plate is reassembled in the piston. Always replace the meter-pin in the same piston from which it was removed. Having withdrawn the valve-plate from the piston, the recuperator valve should be carefully examined.

In some models the recuperator valve disc is riveted to the valve plate, in other types the disc is held against the plate by the plate-retaining spring. Dealing with the riveted type first, if a particle of solid matter is found trapped between the disc and the plate, it should be carefully removed by a feeler of approximately ·005 in. thick, inserted between the two. It should be noted that a minute particle under the disc will prevent its seating properly. Avoid raising the disc more than necessary or it may become distorted. If the disc is found to be broken or distorted, a new valve-plate complete with discs must be fitted. The type of recuperator disc which is held in position by the retaining spring may be removed from the plate and wiped with a clean rag to remove any particles which may be under it ; the face of the valve-plate should also be wiped clean. If the disc is found to be damaged a new one should be fitted.

Trouble caused by the Pressure Valve

If the recuperator disc is found to be free from obstruction and in good condition the trouble is probably being caused by the pressure valve. The construction of this valve is such that a garage repair is not a practical proposition, and the remedy is to fit a new valve-plate complete with discs. This may be obtained from the manufacturers, but it is most important, when ordering, to quote the symbol number which is stamped on the outside of the shock-absorber, and also to state for which end of the unit it is required, i.e. for operation during compression or recoil of the road spring. As an alternative to quoting the symbol number of the shock-absorber, the details of the car from which it was removed may be given thus : " One valve-plate assembly complete (road spring recoil side) for shock-absorber removed from 1939 Morris 10-h.p. Offside Front." When fitting the new valve-plate to the piston, great care must be taken to avoid distorting the recuperator-valve disc. An ordinary flat washer placed over the disc whilst the plate is being pressed home will give protection. Discretion must be used as to whether it is necessary completely to flush out the shock-absorber before reassembling the end cap. If the fluid appears perfectly free from solid matter, the valve-plate may be reassembled to the piston and the gasket, end-plate and end-cap refitted. No jointing compound should be used when fitting the end-cap gasket.

Reassembly of the Unit

It will be seen that serrations are formed in both the end of the cylinder and in the end-plate. A fluid-tight joint is made when the gasket is pinched between these serrations as the end-cap is tightened up. If it is found that there is a quantity of dirt or foreign matter in the fluid, it is obviously no good reassembling the end-cap until the unit has been thoroughly cleaned out. To do this successfully the top cover, both end-caps, and the valve-plates should be removed ; then thoroughly flush out to remove all trace of dirt. For this purpose the manufacturers use trichlorethylene, but if this is not available paraffin may be used as a substitute. After flushing, an air blast should be used. In most models a wire gauze filter is fitted behind the valve-plate. The filter should be cleaned so that the fluid may pass through it freely. The unit may now be reassembled and filled with the correct fluid.

Dealing with Press-fit Valve-plates

We come now to the type of valve-plate which is not retained in the piston by a spring clip but is made a " press fit " in the piston. With this construction the fit of the plate has to be of sufficient tightness to retain it in position, and therefore it is more difficult to withdraw from the piston and to reassemble than the spring-retained type. In view of this it will probably be found most convenient to return this type of unit to the manufacturers for any attention necessitating the removal of the valve-plates. If, however, circumstances call for this job to be carried out as a service repair, great care must be taken in withdrawing the valve-plate ; the best method is as follows : There is a tapped hole (size No. 5BA) in the plate into which a withdrawal screw may be inserted, and a " pull " exerted by leverage against the end of the piston. It should be noted that the withdrawal load must not be taken against the end of the cylinder or damage will result. A short piece of thin tube, about $\frac{1}{16}$-in. wall thickness and the same diameter as the piston, should be placed against the piston end to take the load. Having withdrawn the plate, proceed as with the spring-retained type.

Dismantling and Reassembly of Lever Arm and Connecting Link

The lever arm and connecting link are robustly constructed, and the special rubber bearings have a long life, so that repairs to these parts are seldom necessary. We will, however, describe the procedure for dismantling and reassembling in case the necessity should arise for fitting a replacement. The lever arm is a " force fit " on the shaft serrations, and the end of the shaft is staked or riveted over in three places to retain it. This type of lever-arm fixing is very efficient, but occasionally a lever will work loose. In the majority of cases, when this occurs, the serrations of both the lever arm and the shaft become damaged.

Therefore a shock-absorber with a loose lever should be returned to the makers complete with the arm and link for repair.

The connecting-link bearings are assembled with special tools, the rubber being under high compression. In the event of its becoming necessary to fit a new connecting link, rubber bush, or connecting-link pin, the old rubber should first be pressed out, under a small press. To assemble one of these bearings, a set of three special tools is necessary, i.e. a guide funnel, a punch, and a tapered guide-pin. It is possible to do this job by hand, but it can be carried out much more conveniently under a small press. The first operation is to press the rubber bush into the boss of the lever. To do this the guide funnel is used. It has a tapered bore down which the rubber bush is pressed by the punch into the hole in the lever as shown in Fig. 9. The next operation is to assemble the connecting link or pin into the rubber. To do this the tapered guide-pin is attached to the connecting link or pin, which is then forced smartly downwards into position by the press, as shown in Fig. 9A. The parts, including the rubber, should be washed in paraffin before assembly to remove all traces of grease and dirt, and should be taken direct from the paraffin bath on to the assembly fixture.

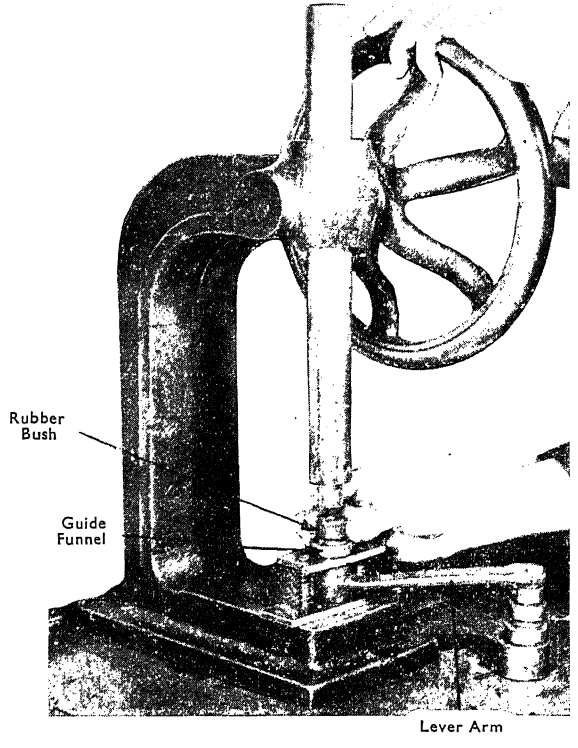


Fig. 9.—ASSEMBLING THE CONNECTING-LINK BEARINGS (1)

Dealing with Faults in Single-acting Piston Type

The methods of dealing with the faults which may arise in the single-acting piston type are similar to those already described for the horizontal double-piston type, with the following exceptions. When the top cover of the single-acting type is removed, the piston may be completely withdrawn from the cylinder if the coupling yoke is prised upwards sufficiently

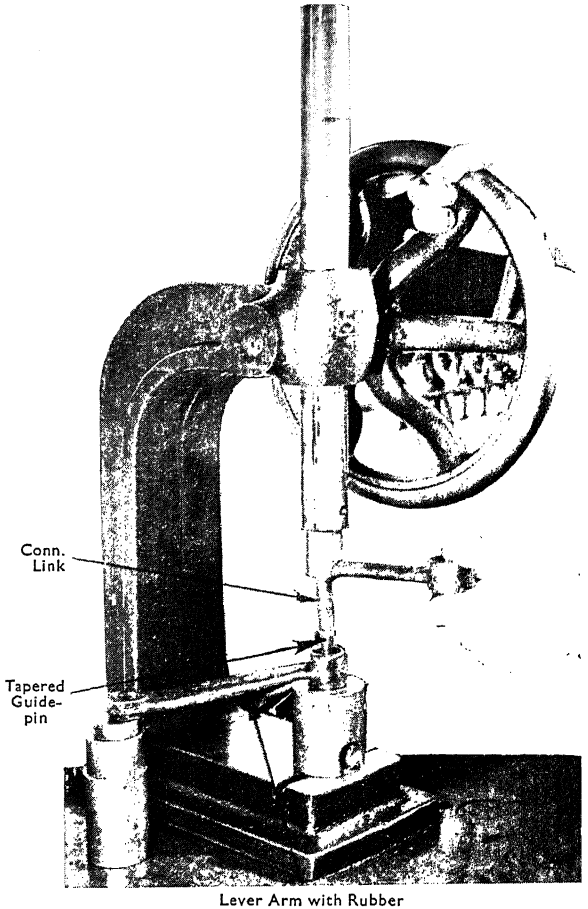


Fig. 9A.—ASSEMBLING THE CONNECTING-LINK BEARINGS (2)

to permit the transverse pin in the rocker arm being withdrawn. It will be seen there are two slots in this pin, into which the yoke locates. There are two small lugs on the side of the coupling yoke, under which a tool may be inserted to prise it upwards as shown in Fig. 10. Having disengaged the coupling yoke, the rocker arm may be swung backwards and the complete piston assembly withdrawn. As in the case of the horizontal double-piston type, the "bleed" hole with its meter-pin is situated near the valve end of the piston. On withdrawing the piston from the cylinder, this meter-pin should be carefully removed, to prevent its falling out and becoming lost. Make sure the same pin and piston are used when reassembling, as they have been graded with the cylinder bore to give the correct resistance. The lever arm and connecting link are of similar construction to those used with the horizontal double-piston type already described.

Maintenance of Vane Types

The maintenance work necessary with the vane type is, with the two following exceptions, the same as already described for the piston types.

Firstly, it is very important that only Luvax Vane Type Thick Fluid is used in the Luvax vane-type shock-absorbers. This fluid differs very

widely from the Piston Type Thin Fluid, and the two will not mix.

Secondly, in the vane types the correct fluid-level is obtained by filling to within approximately ¾ in. of the top of the outer casing. It is important that care be taken to avoid overfilling, otherwise leakage will occur when the fluid expands, as it heats up to working temperature, which is approx. 90° F. It is sometimes rather difficult to see the fluid-level inside the casing, but a convenient method to adopt is to fill to the top and then pour out about one tablespoonful. Move the lever arm by hand. If there is any free movement, the arm should be worked up and down. This will have the effect of drawing fluid from the recuperator chamber, through the recuperator valves, to the working chamber, and the free movement will be felt to become smaller and smaller until it disappears. While doing this, the lever should not be moved beyond the point where fluid resistance is felt; that is to say, only move it up and down to the extent of the free movement.

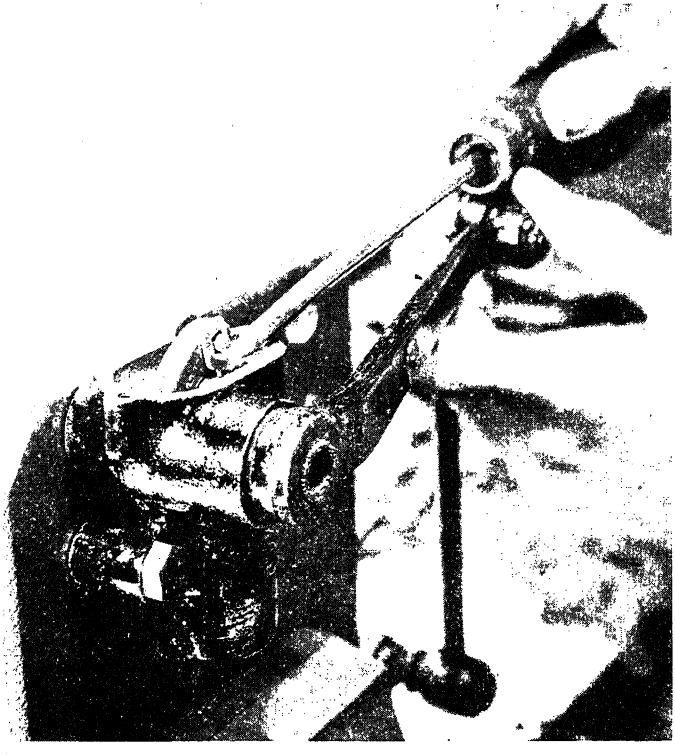


Fig. 10.—SHOWING HOW THE COUPLING YOKE IN THE SINGLE-PISTON TYPE MAY BE DISENGAGED

Service Repairs of Luvax Vane Types

Similar remarks apply to vane-type repairs as to those we have already made in connection with piston types, i.e. it is advisable under normal circumstances to return a faulty unit to the manufacturer for repair or replacement. Should, however, an instance be met with when there is no time available for this procedure, the following repairs may be carried

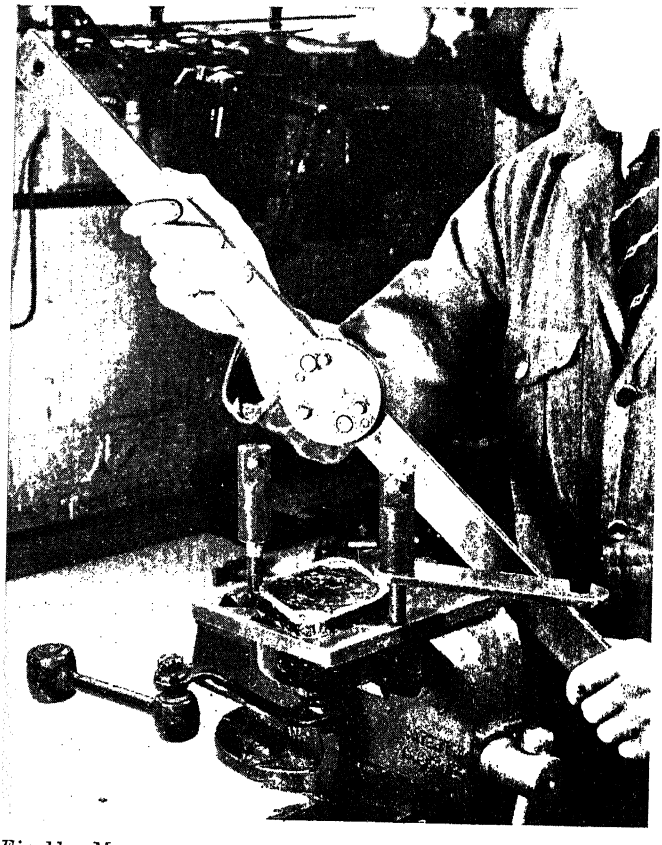


Fig. 11.—METHOD OF TIGHTENING THE BOTTOM COVERS IN VANE TYPE (1)

out in the garage with the aid of a few special service tools.

Fluid Leakage

The only high-pressure joint is at the point where the bottom cover screws into the working chamber. Leakage at this point may usually be remedied by tightening the bottom cover. This operation requires a special spanner on which are formed projections which locate in a recess in the bottom cover. In addition to this a simple fixture is needed, as shown in Fig. 11; it comprises a plate to carry the shock-absorber and a clamp bar to hold the spanner projections in engagement with the bottom cover. The fixture should be held firmly in a vice, as shown in Fig. 11A, and the bottom cover screwed down into the working chamber as tightly as possible. If tightening the bottom cover does not prevent the leakage, it may be that a new gasket is required. Spare gaskets, which are made of a special rubber, may be obtained from the makers. When fitting one of these, the bottom cover should be unscrewed from the working chamber and the old gasket removed. The new gasket should then be stretched into position over the spigot of the bottom cover, care being taken to see that it is quite flat. Smear the gasket with shock-absorber fluid before screwing the bottom cover into the working chamber; this prevents the gasket from buckling when tightening down.

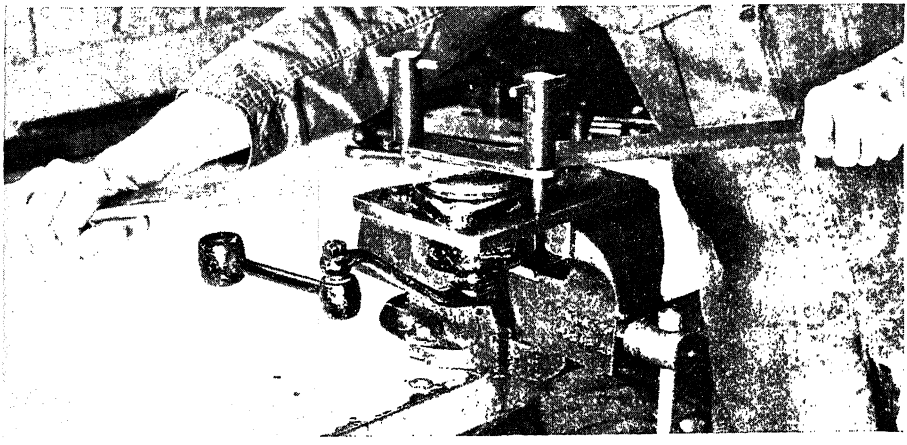


Fig. 11A.—METHOD OF TIGHTENING THE BOTTOM COVERS IN VANE TYPE (2)

Should leakage occur at the joints between the recuperator chamber and the working chamber, the unit should be returned to the manufacturers, as the repair involves the fitting of a new recuperator chamber, which requires special plant.

On all Luvax vane-type models manufactured since approximately 1933, the gland is of a similar construction to that used in the piston type already described, and requires no attention throughout the life of a shock-absorber.

Loss of Resistance

If resistance has been lost, and cannot be restored by "topping up" and expelling the air as described under "Maintenance," it may be due to the internal valves having become stuck up. This may be caused by incorrect fluid having been used which has congealed, or dirt having been allowed to enter through the filler-plug hole. The remedy is to thoroughly flush out the shock-absorber with paraffin. If a bottom-cover spanner and fixture are available, the bottom cover should be removed and the working chamber flushed out. The recuperator chamber should also be flushed through the filler-plug hole. If a bottom-cover spanner is not available, the working chamber may be flushed out through the adjusting-screw hole. To do this, remove the filler plug and adjusting screw, but first of all note the number of turns it is opened from the fully shut position, then turn the unit upside down to drain the recuperator chamber, also work the lever arm upwards and downwards to expel the old fluid from the working chamber. Now pour in paraffin and thoroughly flush both chambers, again working the lever up and down. Make sure that the paraffin is all drained out before refilling with the recommended fluid. To refill, inject with a clean oil-gun as much fluid as possible down the

adjusting-screw hole. Then replace the adjusting screw and adjust it to its original position. Refill the recuperator chamber and recuperate the working chamber by working the lever arm up and down as already described.

Loss of resistance will also occur if the bottom cover has worked loose, as this allows the fluid to pass around the end of the rotor vane. The bottom cover should be tightened as already described under "Fluid Leakage."

Adjustment

Each shock-absorber is adjusted in the makers' works to suit the car to which it is to be fitted, and it is advisable to retain this "setting" unless special conditions are to be catered for. If the original "setting" has been lost owing to the adjusting screw having been moved, an approximate adjustment may be obtained by screwing it down to the fully shut position and then slacking it back two complete turns. The best setting can afterwards be determined by road test with the shock-absorbers refitted. Turning the screw downwards increases the resistance and turning upwards decreases it. The screw is locked every one-sixth of a turn by a spring. The adjustment is very sensitive; therefore, do not move the screw more than half a turn at a time when making adjustments on the road.

Lever-arm Fixing

On certain types the lever arm is secured to the rotor shaft by a cotter bolt. Should the cotter work loose without damaging the shaft, a remedy may sometimes be effected by driving the cotter farther home and tightening the securing nut. In most cases, however, it will be found necessary to fit a new cotter. Replacements may be obtained from the manufacturers. A cotter flat is formed on both sides of the shaft. If it is found that the presence of a loose cotter has worn the flat on the shaft, the difficulty may be overcome by changing over the shock-absorber from one side of the car with that from the other, so that the cotter bolt will be located in the flat on the shaft which has not previously been used.

On other types the lever arm is mounted on a splined shaft and held on by a nut. Should an arm of this type work loose, it may be because the nut is not sufficiently tight, but if tightening the nut has no effect, the unit should be returned to the makers for repair.

The connecting-link bearings are of the same construction as those used with the piston-type shock-absorbers, and similar tools are used for their assembly.

SERVICE QUERIES

Before leaving this subject it will be of interest to consider some shock-absorber queries which may be received in service.

Complaints of Bad Riding

It is an unfortunate fact that a very large number of motorists have a completely mistaken idea as to the correct function of the shock-absorber, and if "the ride" of their cars is not just as they think it should be, they immediately attribute it to inefficient shock-absorbers. Most of our readers have probably met the type of man who will drive in and say, "My shock-absorbers are not working." On being asked for details, he makes a reply such as, "My wife felt sick when riding in the car on the way home from the coast last week-end." He has not troubled to check the resistance of the shock-absorbers, nor to check any of the other factors which have a pronounced effect on "the ride"—such as tyre pressures, shackle and spring lubrication, etc.—nor to make allowance for the human factor, in that both he and his wife were tired after a long day's run, but has assumed the shock-absorbers were not doing their job. It is, then, no good to accept a client's statement such as this, but it is necessary to investigate all the factors which influence the "ride performance."

Are Tyre Pressures Correct?

When describing the function of the shock-absorber we made a brief reference to the fact that the tyres form a part of the suspension system. It is not generally appreciated how important a part they play. The most perfectly sprung car may be made uncomfortable if the tyre pressures are not correct. One of the first items to check, when a complaint is received of "uncomfortable riding," is the tyre pressures; they should be in accordance with the car manufacturer's recommendation.

Other points, such as spring shackles, should also be looked at.

Testing Resistance of Shock-absorbers by Hand

The shock-absorber connecting links should be disconnected and the lever arms worked by hand. The resistance should be uniform in any one shock-absorber throughout the stroke of the lever and the near-side and off-side approximately the same. It should be noted that the word "approximately" is used. This is because when moving the lever by hand it can be moved at only a very slow speed; under these conditions the "feel" is influenced by such things as gland friction, etc., and the actual amount of hydraulic resistance which is exerted at road speeds may not be truly represented. Providing the resistance is uniform throughout the stroke and the off-side and near-side do not differ widely at hand speeds, they may be taken as satisfactory.

Standards of Ride Performance

Complaints of bad riding are often made by people who are expecting too high a standard and, on investigation, it is found that the performance of the car complained of is typical of that particular model, and is as the

car manufacturers intended. In many of these cases the customer is satisfied by the assurance that the various items concerned have been checked over and found correct, and a road test has shown that the ride performance is up to standard.

The garage engineer should concentrate on determining if the " riding " of the car is as its makers intended ; that is to say, is it consistent with the performance of other cars of its type ? It is not advisable to attempt to alter the characteristics of a car's suspension to meet an individual client's ideas without first pointing out that he is asking for a departure from the standard specification.

Investigating Noisy Shock-absorbers

Occasionally a car may be brought in with the owner complaining that the shock-absorbers are noisy. This needs carefully investigating. The bolts which secure the shock-absorbers to the chassis should be checked for tightness, and if the shock-absorbers are mounted on brackets, the bolts or rivets holding the brackets to the frame should also be examined. The anchorage of the lower end of the connecting links to the axles and the connecting-link bearings are further points which should be looked at. If the various bolts or rivets are tight, the shock-absorber connecting links should be disconnected and each lever arm moved by hand. If there is free movement of the arm it denotes lack of fluid and/or air in the pressure chambers. If this condition exists, a noise may be caused by the piston or vane " slapping " against the fluid after passing through the air-gap. The remedy is to " top up " with the recommended fluid and work the lever by hand to expel the air and recuperate the working chamber as already described. A case may be met with, however, where no free movement is present, or where " topping up " with fluid has dispelled the free movement of the arm and the resistance is uniform throughout the stroke—but the noise continues. Obviously a further search must be made. It is well known how difficult it is to locate a noise whilst driving, and the client may have been mistaken in his diagnosis. A simple method of determining if the noise is in the shock-absorbers or not is to take a short run on the road with each shock-absorber connecting link in turn disconnected. If a noise is present when one of the links is connected and absent when it is disconnected (and the fixing bolts are tight and the linkage correct), the noise is located as being in that particular unit. The noisy shock-absorber should be removed, and if it cannot be corrected by the usual maintenance methods it should be returned to the manufacturers, as some internal mechanical fault will have developed. A loose lever arm may also cause noise ; the remedy for this is described under " Repairs."

A word here of the importance of expelling the air from the pressure chambers of the piston-type units before refitting them to the car. It is

imperative that all air is expelled by working the lever arm up and down through the full stroke, and, furthermore, after expelling the air, the unit must not be left lying on its side before fitting, otherwise air will re-enter. When all the air has been got rid of, the unit should straight away be bolted into its place or stood in its working position until it can be fitted.

" Rolling on Corners "

A further trouble which may be reported in the form of a shock-absorber complaint is " rolling on corners." It should be clearly understood that the shock-absorbers are not intended to act as an anti-rolling device. A little thought will show why this is so. We have already explained that hydraulic resistance increases with speed ; now, rolling is a slow movement, and this causes the shock-absorbers to offer only a low resistance, if they are adjusted normally. Assuming that they could be adjusted to offer sufficient resistance to prevent slow speed roll, the amount of damping for normal straight ahead conditions would be excessive and the result would be a very harsh, uncomfortable ride. The prevention of rolling does not come into the sphere of the shock-absorbers' duty. In fact, a large number of well-known car manufacturers are now fitting hydraulic shock-absorbers to damp the road springs and anti-roll torsion bars to prevent " rolling on corners."

REMOVING DENTS FROM WINGS AND PANELS

BY HOT-METAL SHRINKAGE

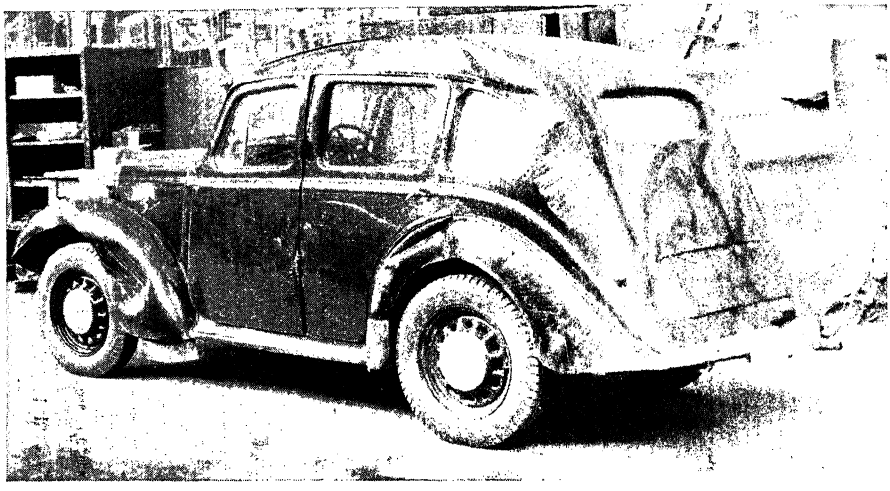


Fig. 1.—BODY WITH BADLY DAMAGED SIDE

A completely new side can be welded in after squaring up the body and cutting away the damaged parts. However, by the process of hot metal shrinkage, it is possible to repair damaged panels that might otherwise require replacement.

MODERN bodies with their welded panels and high-crown wings have hitherto presented a real problem in the repairing of damaged panel sections in which the metal has been stretched. The replacement of body panels is a long and tedious job, but by the use of the process of hot-metal shrinkage it is possible to repair damaged panels that might otherwise have required replacement. This process is particularly adaptable to high-crown wings—and this fact alone makes the mastering of this process well worth the time involved. The process of hot-metal shrinkage is the quickest, most simple, and most efficient method of restoring stretched body sheet metal to its original contour.

By a careful study of the process, step by step, and a little practice on old wings or body panels, hot shrinkage can be mastered in a relatively short length of time. We are indebted to the firm of General Motors Ltd. for the information upon which this article is based.

Where Hot Shrinkage can be Applied

Complete hot shrinkage can be accomplished only where it is possible to obtain a complete circular pressure around the stretched section of the metal. This can be done on all body panels, wings, and any high-crown panel. This circular pressure is created in a bound or anchored panel, or in a high-crown panel, when a damaged section is hammered out into the shape of a stretched bulge. Hood panels are the only body panels on which complete hot shrinkage is not assured. This is due to the fact that hood panels are of low-crown contour, and that they have no return flanges or inner construction by which the panels are supported, or to which they are anchored. Therefore, it is not possible to set up a complete circular pressure. For this reason it is possible to obtain only about 60 per cent. to 70 per cent. hot-shrinkage efficiency on unbound panels.

Hot shrinkage cannot be applied to sheet aluminium.

How Hot Shrinkage Occurs

After the metal has been hammered out into the form of a stretched bulge, heating a spot at the highest point of the bulge to a cherry-red heat releases the pressure at the centre and allows the shock of spring hammering to force the metal to upset, and also sets up a pressure opposite to the circular pressure.

With this opposing pressure set up, by allowing the metal to cool for about 10 seconds after the spring hammering, then quenching with a water-soaked sponge, the metal is forced into a circular draw, which draws it to the approximate shape of the original contour.

Some mechanics may have a tendency to become panicky when they see the heated spot begin to buckle and wrinkle upon applying the spring-hammer blows. However, the shock of these blows is what forces the metal to upset, and each time the heating, spring hammering, and quenching are applied to the stretched bulge, over half of the spring-hammered portion is drawn back, or shrunk, to its original contour. The kinks and wrinkles that appear so troublesome will rapidly be erased when the hammer and dolly block are used in the smoothing-out operation.

Instructions for Carrying Out Hot Shrinkage

For the purpose of explaining the process of hot-metal shrinkage, step by step, the following instructions, with their accompanying illustrations, will serve to clarify the process so that it is easily understood.

Fig. 2 shows the damaged section of the panel with the metal stretched and jammed inwards. It is apparent from the drawing that the metal has been stretched, and that in order to smooth out the panel to its original shape, something will have to be done with the stretched metal.

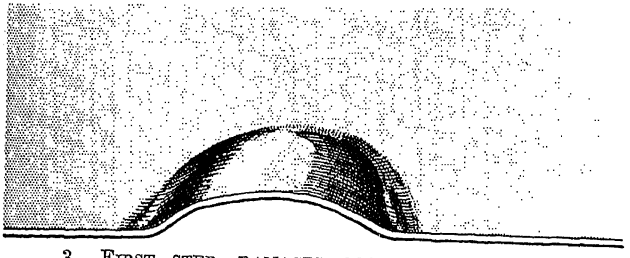


Fig. 2.—DAMAGED SECTION OF PANEL

The First Step—Roughing Out

The first step in the operation is to rough out the damaged section of the panel into the form of a stretched bulge, as shown in Fig. 3. This creates a complete circular pressure around the bulge, which is necessary to complete the hot-shrinkage process.

Next get a pail of water, a medium-sized sponge, and a mallet, and place them so that they may be easily and quickly reached when needed. This is most necessary, for the various steps in the operation must be done at the proper time, as very little time elapses between each step.



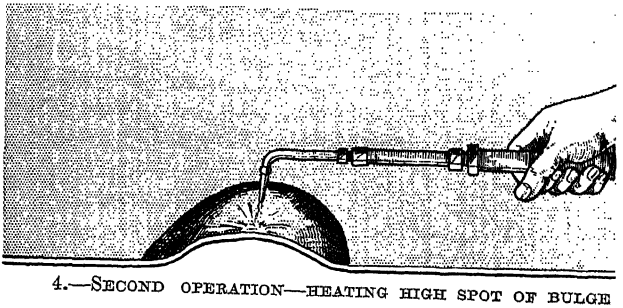
3.—FIRST STEP—DAMAGED SECTION ROUGHED OUT TO FORM A STRETCHED OUTWARD BULGE

Second Operation—Heating

Next heat a spot, about the size of a shilling, at the highest point of the bulge, to a cherry-red heat, as shown in Fig. 4. For this purpose use an acetylene torch with a small sheet-metal tip. Care must be taken not to get the metal too hot or it may be burned.

Third Operation—Spring Hammering

Then strike the hot spot about six quick, medium-hard blows with the mallet, Fig. 5. This forces the metal at the centre of the bulge to upset and drop down. *Do not* use a dolly block or any other backing-up tool while applying the blows with the mallet. The fact



4.—SECOND OPERATION—HEATING HIGH SPOT OF BULGE

that no backing-up tool is used is the reason for the term "spring hammering."

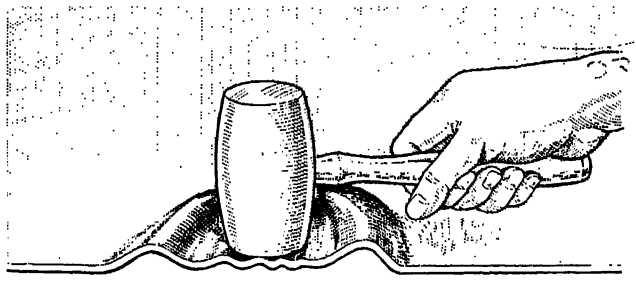


Fig. 5.—THIRD OPERATION—SPRING HAMMERING THE HOT SPOT

Fourth Operation —Quenching

Allow the metal to cool for about 10 seconds, then apply the sponge with all the water it will hold, pressing down hard on the spot that was heated and spring hammered. This is shown in Fig. 6.

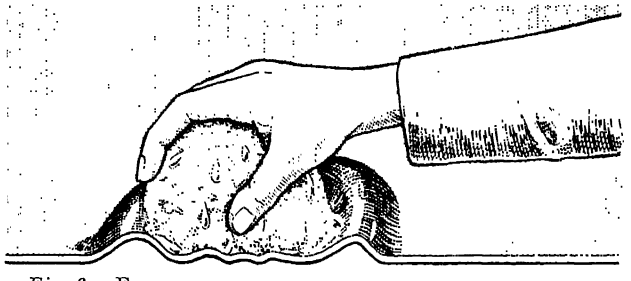


Fig. 6.—FOURTH OPERATION—QUENCHING THE HOT SPOT

Fifth Operation— Smoothing

After the panel has cooled, use a panel hammer and the proper dolly block to smooth out the shrunk portion of the metal, as shown in Fig. 7. This stiffens the metal and sets up pressure to aid in further shrinking. After this operation, the operator will notice that over half of the stretched bulge has been eliminated. The portion of the bulge that is taken out in any one heating, spring hammering, and quenching operation, will obviously depend on the size of the stretched bulge.

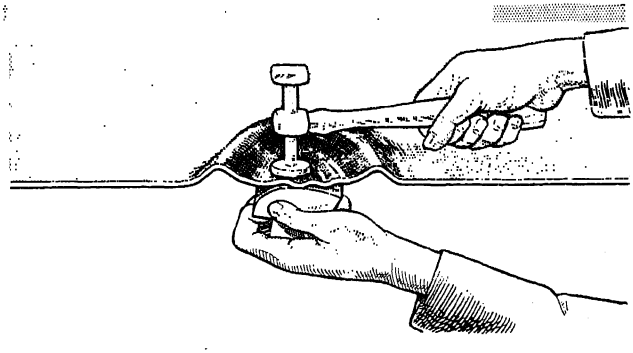


Fig. 7.—FIFTH OPERATION—SMOOTHING OUT SHRUNK PORTION OF METAL

Dealing with the Ridge

It will be seen from Fig. 8 that the shrunk portion of the metal is in the centre, and the remaining part of the stretched bulge is in the form of a ridge

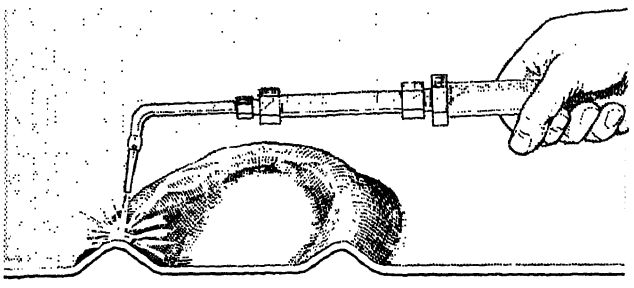


Fig. 8.—HEATING HIGH SPOT OF RIDGE

around the shrunk part.

Next heat a spot on the highest point of the remaining part of the bulge, about the size of a sixpence, to a cherry-red. This is shown in Fig. 8.

Then strike the heated spot about six quick, medium-hard blows with the mallet, as shown in Fig. 9.

Allow the metal to cool for about 10 seconds, then quench the hot spot by pressing the water-filled sponge on the spot, Fig. 10.

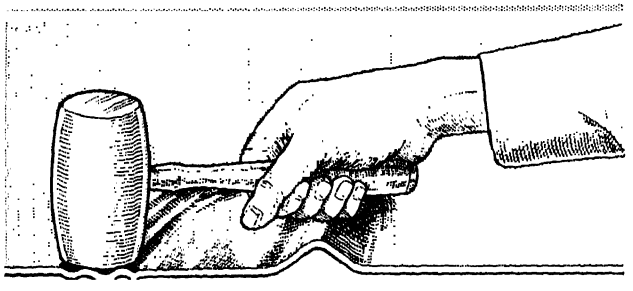


Fig. 9.—SPRING HAMMERING HOT SPOT ON RIDGE

Then, after the metal has been allowed to cool, smooth out this shrunk portion of the metal with a bumping hammer and dolly block, as shown in Fig. 11.

Completing the Work

On this particular job, this should leave only a small portion of the original bulge to be shrunk. Heat a spot about the size of a sixpence, at the highest point on the bulge, to a cherry-red heat, as seen in Fig. 12.

Give the heated spot about six quick, medium-hard blows with the mallet, Fig. 13.

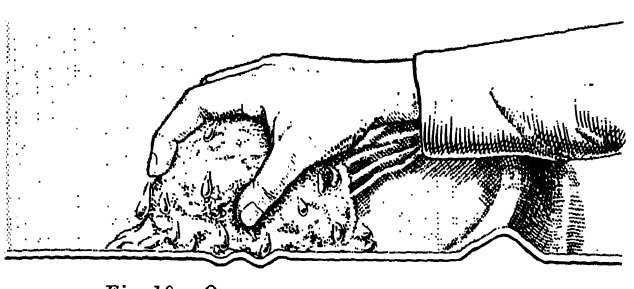


Fig. 10.—QUENCHING HOT SPOT ON RIDGE

Allow the metal to cool for about 10 seconds, then quench the spot with the water-soaked sponge by pressing it hard on the spot, Fig. 14. This will cause the remaining portion of the bulge to

wrinkle and drop down. It must be remembered, however, that the number of heating, spring-hammering, and quenching operations necessary to completely hot shrink the stretched bulge will depend on the original area of the bulge, a smaller area requiring less than a larger one.

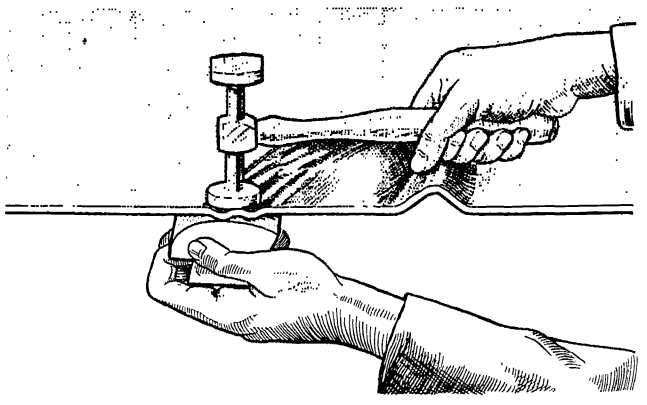


Fig. 11.—SMOOTHING OUT SHRUNK METAL ON RIDGE

Smooth out this remaining portion of the shrunk metal with a bumping hammer and dolly block. The damaged section of the panel is now ready for the finish smoothing out operation and metal finishing in preparation for the painting.

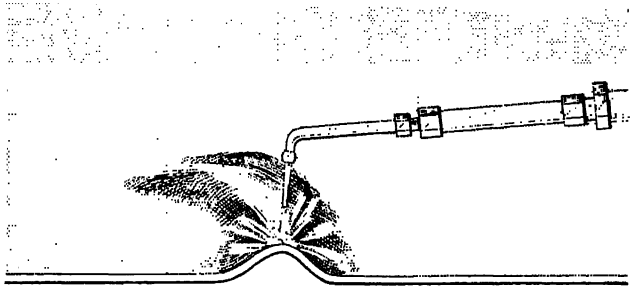


Fig. 12.—HEATING REMAINING HIGH SPOT

Some Final Warnings

Never quench the red-hot spot. Wait until the metal turns black.

Never heat the entire stretched bulge, or heat beyond the point of pressure. Use small heats.

Always hammer the stretched metal outward to form the circular pressure.

If the stretched part is very small, use a small heat.

Never use anything but an acetylene torch for heating.

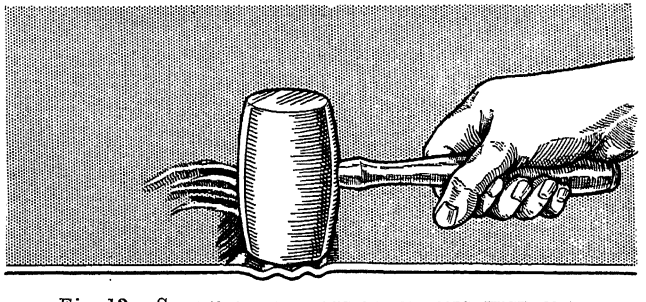


Fig. 13.—SPRING HAMMERING REMAINING HIGH SPOT

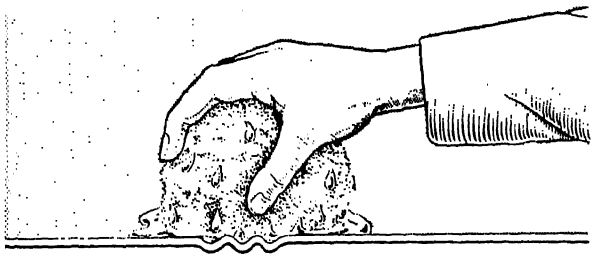


Fig. 14.—COMPLETION—QUENCHING HOT SPOT
Follow this by smoothing as in Fig. 11.

Never attempt to shrink a panel until after the roughing-out operation.

REPAIRING DAMAGED WINGS WHERE HOT SHRINKAGE IS NECESSARY

Wing repairing is not as difficult a job as the damaged metal might indicate. A good job is largely a matter of studying the damage and selecting the proper tools to work the dent out. The operator must always keep in mind the fact that the damaged section must be taken out the same way it went in. The reason for this is that when a wing is damaged, a backward strain—or strain contrary to that set up in the metal when the wing was formed—is set up. This strain must be relieved before the metal can be made to assume its original shape.

To clearly illustrate this job we take a wing that has actually been damaged and follow the steps in its repair, one by one. The wing seen in Fig. 15 is a rear wing that was damaged by being struck in the front, and in passing the car that did the damage pulled out the rear of the wing. The crown is jammed in, and the blow on the rear of the wing caused the outside flange to stretch. For convenience these damaged sections are numbered No. 1, No. 2, and No. 3, beginning with the front of the rear wing.

Cleaning the Damaged Wing

First clean the wing thoroughly with an oil-soaked rag. The purpose of the oil is: first, to reflect the light on to the damaged section, so that every bump and indentation may be readily seen; second, the oil creates a cushion under the hammer and keeps the paint from being picked up by the hammer.

Then clean the underside of the wing of all dirt and tar. If this is not done, the particles will be beaten into the metal when the hammer and dolly block are used.

Next place a piece of white paper on the floor and on it an electric light bulb in such a way that the light is reflected directly on that part of the wing on which the work is to be done. A good light on the damaged section is an *absolute necessity*, for it is obvious that a first-class job cannot be done if the operator cannot clearly see what he is doing.

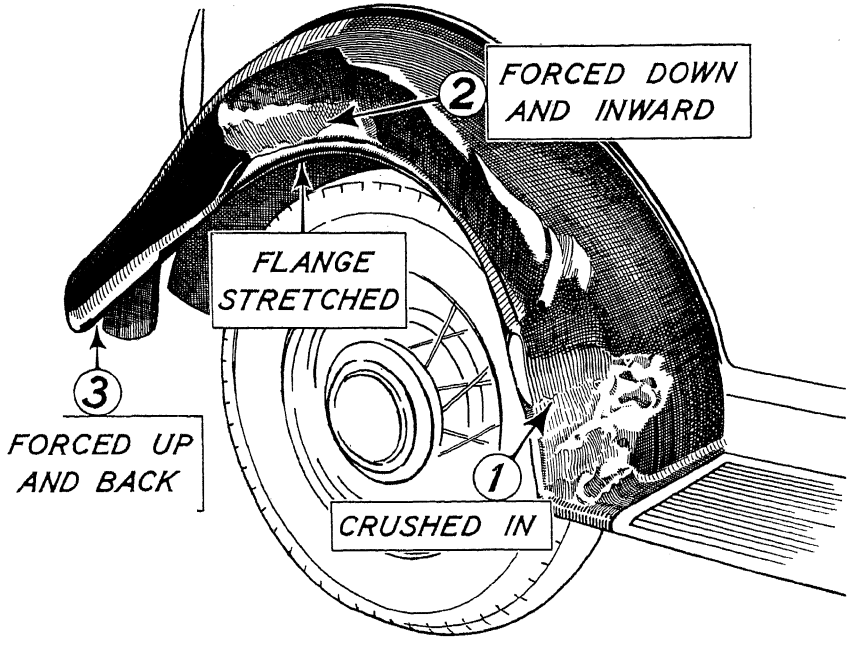


Fig. 15.—TYPICAL EXAMPLE OF REAR-WING DAMAGE
Method of repair by hot shrinking is described in the text.

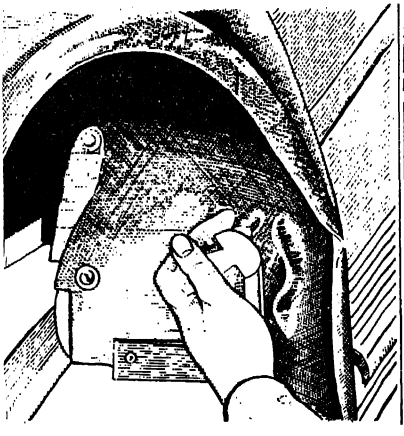


Fig. 16.—ROUGHING OUT DAMAGED SECTIONS OF WING, USING PROPER DOLLY BLOCK



Fig. 17.—ROUGHING OUT SHORT, TIGHT DENTS

Roughing Out

Rough out dent No. 1, using the proper dolly block. Follow the crown of the wing when roughing out this dent. *Never* use a ball-peen hammer to rough out a damaged wing, or the metal will be full of small "bubbles," and a smooth job will be an impossibility. Selection of the proper dolly block will greatly simplify this operation, because the *right* block has the same contour as the wing had before it was dented.

Rough out the No. 2 dent on its natural position. Bring the crown back to its original position to form circular pressure in order to complete hot shrinkage.

The damage at the rear of the wing shows that the rear skirt has been pulled out and also that the rear corner section is pulled out, making a series of short, tight dents. The best method of roughing out short, tight dents is to use two dolly blocks, one held on the bead of the wing to relieve vibrations, and the other to rough out the dent.

After roughing out these tight dents bring the skirt back into alignment by holding a dolly block behind the low spot on the skirt and hammering the skirt back.

It will be noted at this point in the operation that the rear of the wing is loose and not rigid as it was before the wing was damaged. Hot-metal shrinkage at dent No. 2, in connection with pressure applied at the rear end of the wing, will not only shrink the stretched metal at this point, but will also draw the skirt of the wing in and make it rigid.

Hot Shrinking

To perform this operation, apply pressure to the rear of the wing, using a 2 × 4-in. length of wood as a lever. Then, in the centre of the stretched part of the crown, at the highest point of the bulge and about 2 in. up from the bead, heat a spot about the size of a shilling to a cherry-red heat. Never heat on the bead. Hit the spot about six quick, medium-hard blows with a mallet, and after allowing the spot to cool for about 10 seconds, quench by applying a water-filled sponge.

The pressure must be applied to the rear of the wing throughout the entire hot-shrinkage process. This is important.

If there are any breaks or cracks in the wing they must be welded before the hot-shrinkage operation.

Bump out the shrunk section, using a dolly block and a bumping hammer or mallet. Hold the dolly block loosely on the low spots underneath the wing, and strike the high spots on the outside with the hammer or mallet. This method causes the dolly to spring back against the low spots and readily smooth them out.

If the wing does not set square or is not shrunk enough, apply more pressure and repeat the process. Always heat on the highest part of the bulge.

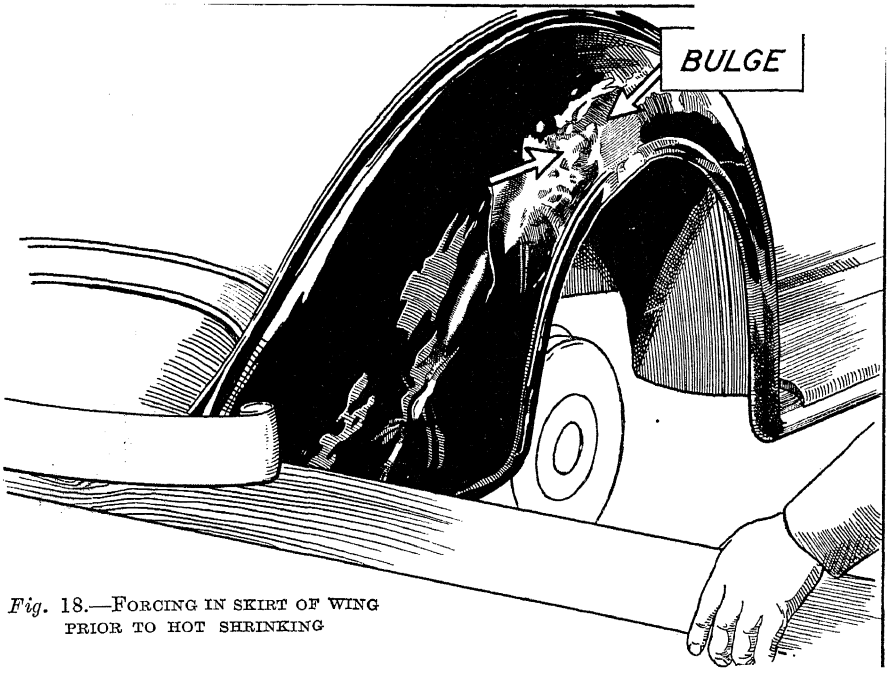


Fig. 18.—FORCING IN SKIRT OF WING PRIOR TO HOT SHRINKING

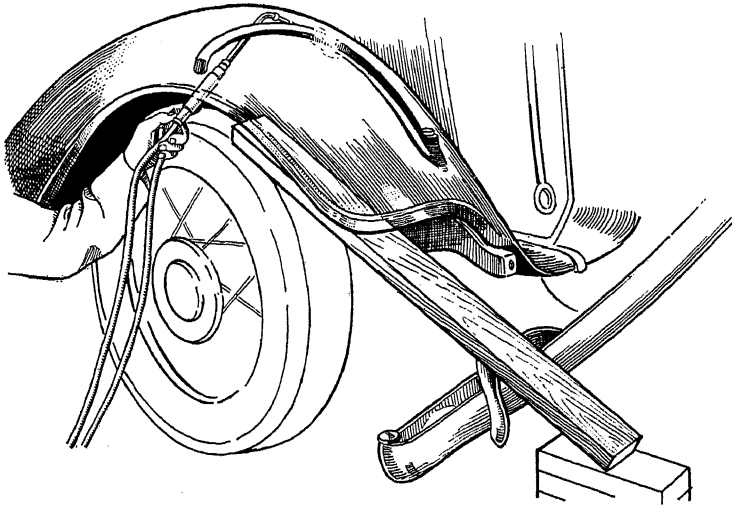


Fig. 19.—RELIEVING STRAIN AFTER FRONT-WING DAMAGE
Showing flange lined up while bracket is heated.



Fig. 20.—SANDER BEING USED FOR RUBBING DOWN ON A WING ("SPEED-BLOC" SANDER)
Methods of finishing are dealt with in another section of this work.

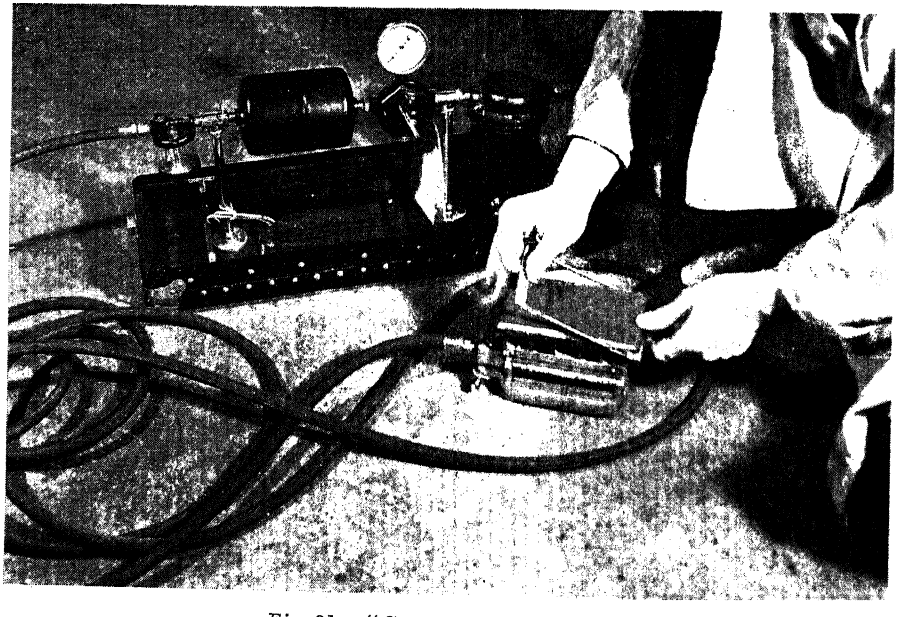


Fig. 21.—"SPEED-BLOC" SANDER
Showing the complete outfit and method of placing new paper on machine. (*Equipments, Ltd.*)

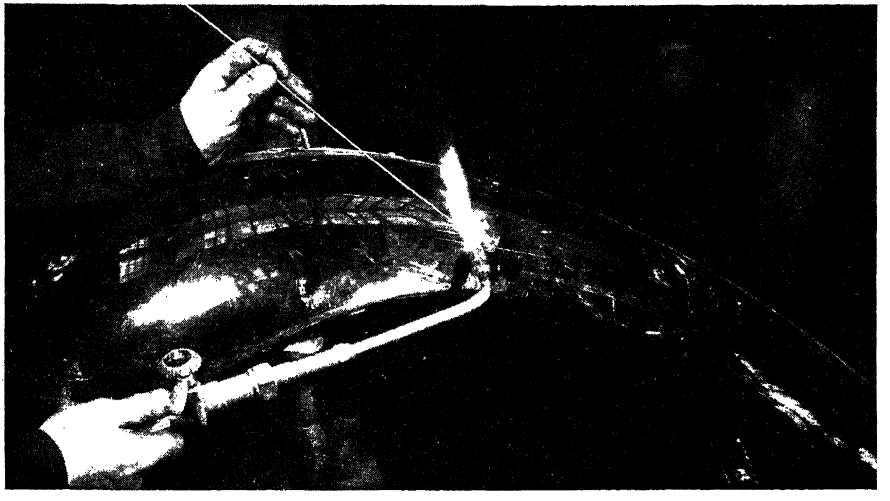


Fig. 22—SPLIT IN WING BEING WELDED

Breaks or cracks in wings must be welded before the hot-shrinkage operation. Welding repairs are dealt with in a later section of this work. (*Equipments, Ltd.*)

Aligning the Bead

To bring the bead into perfect alignment, hold a dolly block behind the low spots and strike the high spots on the bead with a mallet or bumping hammer.

To show up the high and low spots on the rough bumped sections use a long piece of chalk, and holding it flat on the metal, rub the chalk on these sections. The high spots will show up as being white with chalk, while the low spots will be dark or unchalked. Do not file yet.

Checking Smoothness

Finish bumping the sections by holding the dolly block loosely on the low spots and striking the high spots with a bumping hammer. Check the smoothness of the metal by rechalking—if a smooth job has been done the metal will show up as thoroughly chalked.

The metal may now be finished and prepared for painting with a file and disc sander. At the time the file is being used, any small indentations will show up and may be easily tapped out.

Front-wing Bead Split

Most front-wing damage is caused by a front end collision, or a blow directly on the front of the wing. It is not enough to simply repair the damage done to the wing, as the wing bracket is pushed back out of alignment at the same time that the wing is damaged. With this

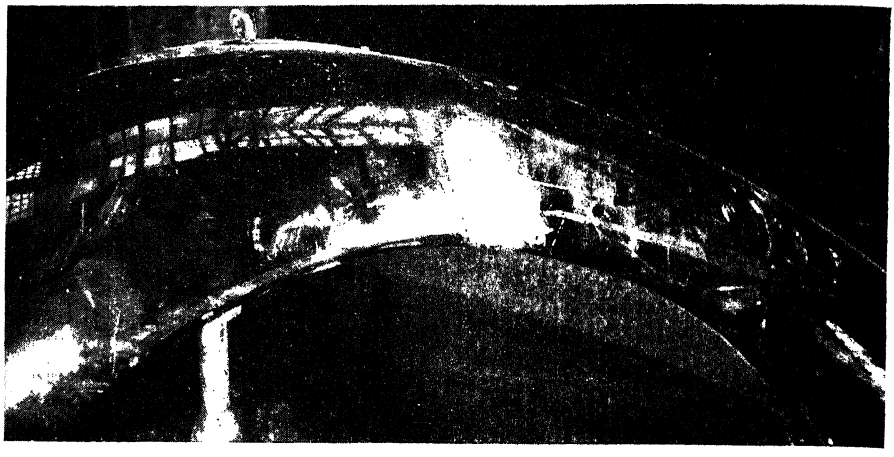


Fig. 23—WELD IN WING COMPLETED AND READY FOR REFINISHING

condition, all of the strain and weight of the wing is thrown on to the outside flange, or bead, causing the metal to split.

To relieve this strain, remove the bumper and place a 2 × 4-in. length of wood on the tyre and under the end of the wing, and pull up on the end of the wood until the bead of the wing buckles into its normal position. Then block the wood in this position. Protect the wing paint with wet asbestos. Heat to a cherry-red a spot about 2 in. long on the back flange of the wing bracket at a point approximately 14 in. from the outside edge of the wing. Also heat a spot about ¾ in. long on the forward flange of the bracket.

With the pressure still applied allow the bracket to cool. This will anneal the bracket, causing the strain to be relieved and preventing the wing from cracking at the bead.

When it becomes necessary to repair cracks that have been caused by failure to relieve the strain in the bracket, it is necessary to weld the break before the bracket is annealed.

Further methods of repairing damaged wings and panels are given later, in addition to methods of finishing.

SPECIAL POINTS TO BE WATCHED WHEN REPAIRING STANDARD CARS

PROPELLER SHAFT, REAR AXLE, FRONT AXLE, STEERING GEAR, ETC.

By B. TURNBULL

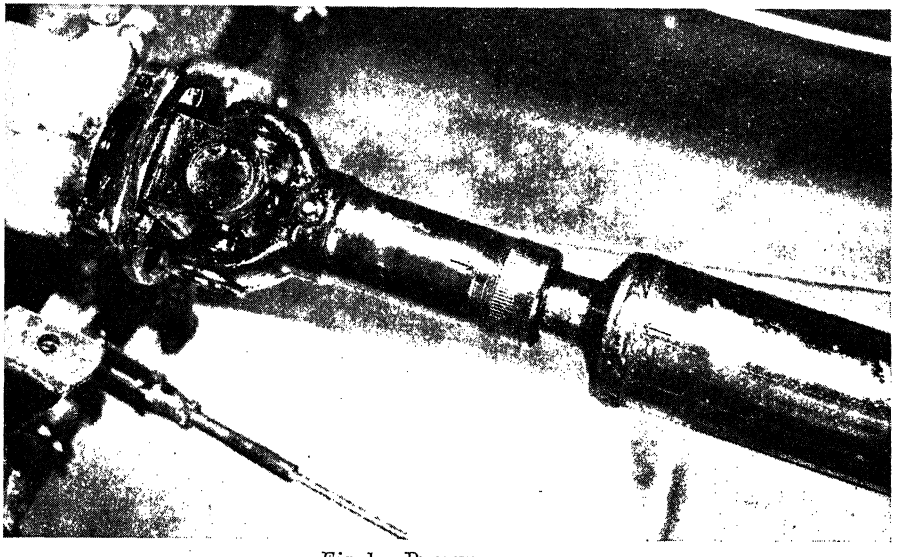


Fig. 1.—PROPELLER SHAFT
Showing arrow markings on propeller sleeve and shaft which must be in line to ensure correct alignment of yokes on axle of gearbox.

PROPELLER SHAFT

THE propeller shaft is a " Hardy Spicer " unit, and the yokes of the universal joints at each end of the shaft are carried on needle roller bearings and housed in steel cups which are filled with lubricant and are said to last the life of the car.

In the event of removing the propeller shaft from the chassis it is important that it be replaced with the sliding-yoke end towards the gearbox ; moreover, if the sliding yoke has been removed from the splines at the end of the shaft it must be replaced again in its original position. This position is indicated by two arrows, one of which is on the body of the

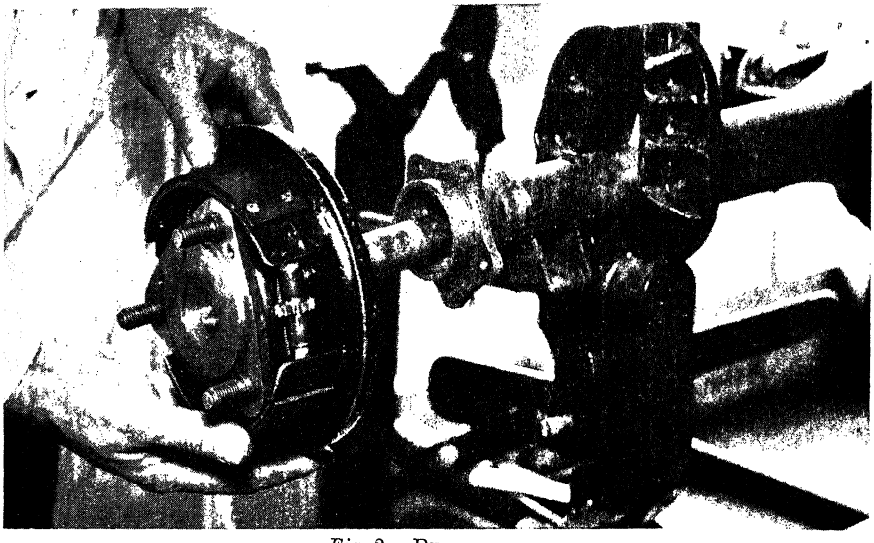


Fig. 2.—REAR AXLE
Withdrawing one-piece rear axle, half shaft and hub.

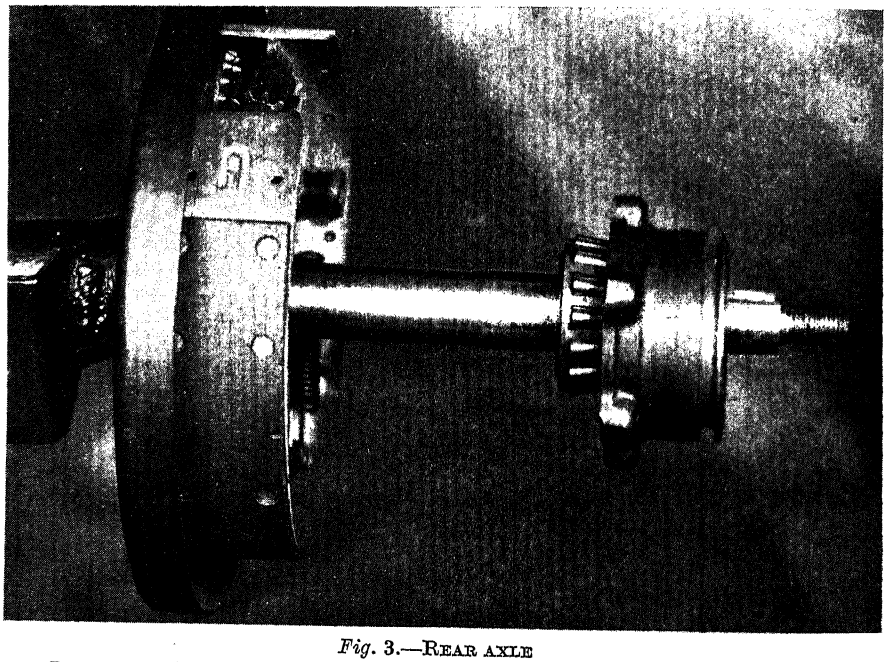


Fig. 3.—REAR AXLE
Removing rear-axle shaft and taper bearing with housing, after withdrawing hub.

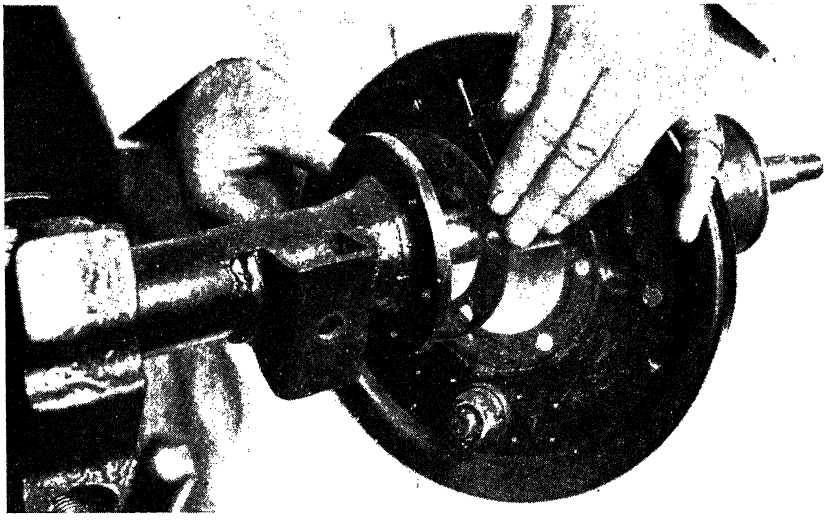


Fig. 4.—REAR AXLE
Fitting packing shims for bearing clearance.

sliding yoke and the other on the body of the shaft. These arrows must be in a line with each other when the sliding yoke has been replaced on the end of the shaft.

REAR AXLE

The rear axle is the orthodox semi-floating type of unit employed on all models, and the chief variation that may be found in respect of the different models is the dimension. However, on the 9-h.p., 10-h.p., 12-h.p., 14-h.p., and 20-h.p. axles the axle shaft and the hub are separate, but on the 8-h.p. axle the shaft and the hub are combined and the hub is therefore not detachable. If, therefore, the hub on the 8-h.p. model becomes damaged through accident or other causes it will be necessary to replace the shaft and the hub.

To Dismantle Rear-axle Unit

To dismantle the rear-axle unit on any model proceed as follows :

(1) Jack up the rear of the car and remove rear road wheels and brake drums.

(2) Disconnect rear brake cables from brake cross-shaft.

(3) Remove nuts and locknuts from rear axle U-bolts and extract bolts and disconnect the plate carrying the pin to which the shock-absorbers are connected.

(4) Disconnect propeller shaft from rear axle.

(5) Remove split pins and undo the nuts and bolts holding brake backing plate to each end of the axle casing.

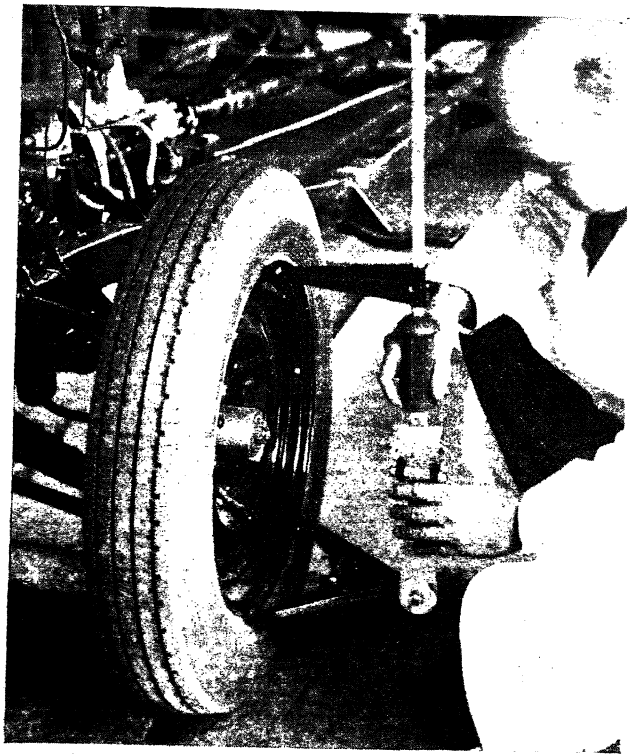


Fig. 5.—CHECKING CAMBER WITH CAMBER GAUGE

The position of the front wheels should be either perpendicular or with a positive camber of $\frac{1}{2}$ degree (independent suspension).

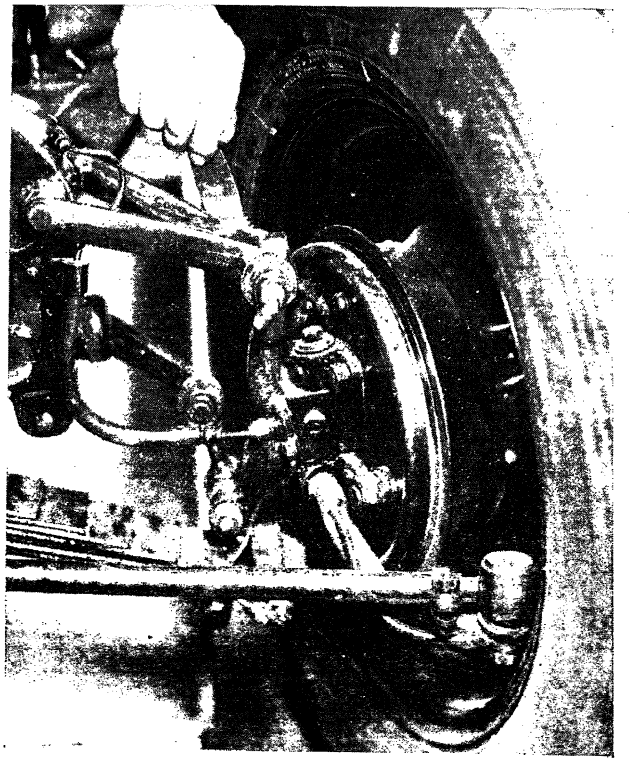


Fig. 6.—ADJUSTING CASTOR ANGLE

Adjusting eccentric bush on front shackle for setting the castor angle. This should be between $1\frac{1}{2}$ degrees and $2\frac{1}{2}$ degrees (independent suspension).

(6) Pull out axle shafts, together with hub bearing, bearing housing, distance shims, and brake backing plate.

(7) Remove nuts and washers which hold the pinion housing in position and withdraw the housing complete with differential.

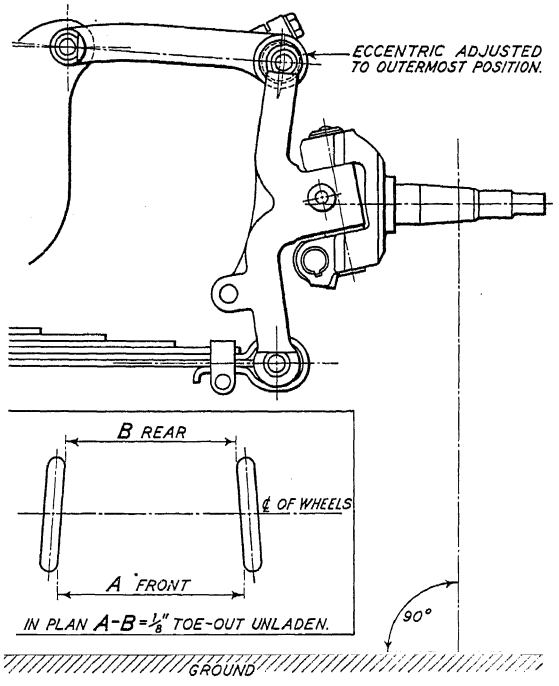


Fig. 7.—INDEPENDENT SUSPENSION ALIGNMENT (ALL MODELS)

It is desirable that wheels be vertical or slightly cambered (outwards at the top). This is usually achieved when the eccentric adjuster is set as shown above. Half degree camber is quite sufficient. Accurate measurements cannot be made if suspension joints are stiff. The castor angle should be between 1½ and 2½ degrees. A small amount of adjustment is available by screwing in or out the eccentric bush shown above.

Fitting New Pinion and Crown Wheel

In the event of having to fit a new pinion and crown wheel the differential will have to be dismantled. It will save the operator time, however, if, during removal of the pinion, the two collars which are known as the bearing adjuster and the adjuster collar be left in their original positions, for by removing the flanged coupling from the pinion shaft the pinion may be ejected from the housing without altering the position of any of the other details. This will act as a guide when inserting the new pinion, which will in all probability take the same position as the old pinion and therefore eliminate the time which is quite frequently spent in endeavouring to adjust the pinion and the crown wheel. When the pinion is inserted in its correct position the end of the pinion teeth should be in line with the inside end of the teeth on the crown wheel, and the backlash existing between the teeth of these two gears should be approximately ·005 in.

Axle Shaft End Float

On replacing the axle shafts on all models, with the exception of the "Eight," the end float on the axle shafts should be adjusted to ·006 in.



'. 8.—STEERING GEAR

Adjusting cam and roller between end cover and box. Note the shims.

FRONT AXLE ASSEMBLY

Re-straightening Axle Beam

The front axle assembly, with the exception of the 8-h.p. and 12-h.p. Super 1939 models, is an orthodox arrangement with the usual axle beam, semi-elliptic springs, stub axles, etc. The axle referred to consists of a 60-ton alloy steel beam, and the important point in connection with it is that in the event of its being bent as the result of a collision, it is essential that when it is straightened it must be re-heat-treated. There can be no departure from this procedure, as failure to do so would reduce the strength of the material, thereby considerably reducing the margin of safety.

Correct Castor Angle of Axle Beam

The axle beam has a castor angle of about 4½°, and this is, on some models, obtained by the insertion of suitable wedges between the spring platform on the axle beam and the road spring.

It is therefore advisable, when dismantling this assembly, to carefully observe the manner in which these taper wedges were originally fitted, so that they go back in exactly the same way. If the taper wedges are fitted incorrectly they are likely to produce either wheel wobble or a tendency for the car to wander. When the wedges are fitted correctly, the king pins at the end of the axle beam should be canted backwards between 2½° and 4½°.

Another important point in connection with the front of the Standard car where the orthodox suspension is employed, is that the track of the front wheels is parallel. Experience shows that this gives the best results, with regard to both stability and tyre wear.

Independent Suspension

On the 8-h.p. and 12-h.p. Super 1939 models there has been introduced a form of independent suspension at the front of the car. This has been

achieved by the aid of a transverse road spring, the ends of which are coupled to the frame through the medium of a swing shackle and an H-section bracket which carries the stub axle. The stub axle itself is orthodox in design and carries "Timken" races which support the hubs and road wheel.

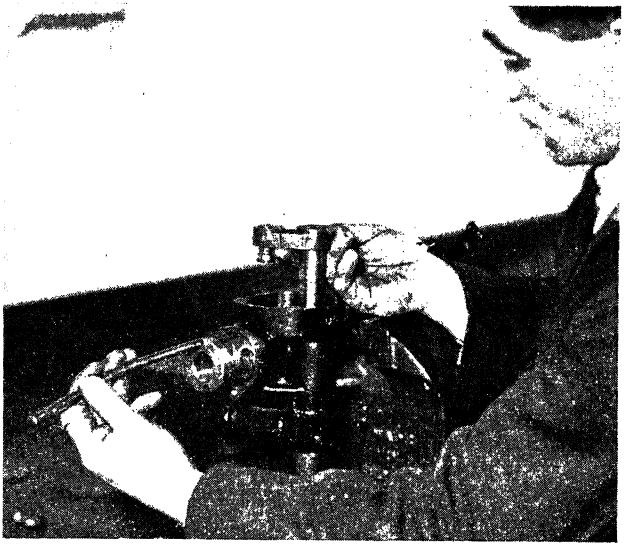


Fig. 9.—METHOD OF REMOVING STEERING SHAFT

The track of the front wheels on this model varies with that of other models, which have orthodox suspension, inasmuch as the two front road wheels toe out at the front $\frac{1}{8}$ in. The castor angle should be between $1\frac{1}{2}°$ and $2\frac{1}{2}°$, and a small amount of adjustment is available by screwing in or out the eccentric bush shown in Fig. 7. The position of the front wheels should be either perpendicular or with a positive camber of $\frac{1}{2}°$. An eccentric bush is provided at the outward end of the swinging shackle and is retained in position by a clamp bolt, and adjustment of the road wheel position so far as the camber is concerned is also provided by adjustment of this bush.

STEERING GEAR

Remedying Wear in "Douglas Burman" Gear

The "Douglas Burman" steering gear is part of the specification of the 8-h.p., 9-h.p., and 10-h.p. Standard cars. It is a nut and worm arrangement, and is so satisfactory in use that no special adjustments are required. After a considerable mileage, however, it is possible for wear to occur on the worm and nut of the steering gear, in which case it is necessary to replace both worm and nut, which are supplied in pairs suitably fitted together. To fit a new nut on an old worm is unsatisfactory, as experience shows that wear which occurs on the worm is concave so that you have the maximum wear in the centre of the worm. If the new nut is adjusted so that it is the correct fit in the centre of the worm the steering will be too tight on the extreme locks, whereas if you adjust the nut to be a fit at the ends of the worm it will in all probability be too slack in the

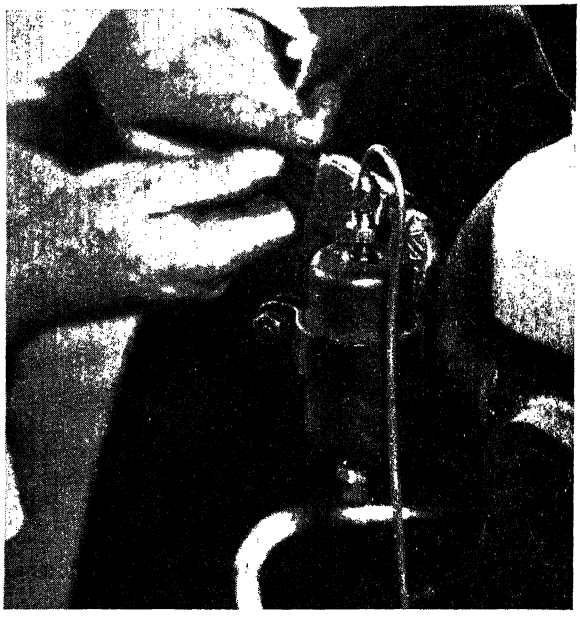


Fig 10.—THERMAL CHASSIS LUBRICATION

Adjusting oil supply by moving expansion chamber nearer or farther away from manifold.

centre, therefore in all cases it is important that a new nut and worm be installed.

Adjusting "Marles" Gear

On the 12-h.p. 1939 model the "Marles" steering gear is in use, and the chief point of importance to observe is that when adjustment is necessary the position of the roller in relation to the cam should be adjusted when the roller is in the centre of its range of movement. The adjustment is carried out by the eccentric bush, which raises and lowers the roller, and the roller should be adjusted so that there is practically no backlash when in the centre of the cam, but it will be observed that at the extreme locks there is backlash present between the roller and the cam and this should be equal at both extreme locks.

Adjustment of "Bishop" Steering Gear

The 14-h.p. and 20-h.p. Standard cars have the "Bishop" steering gear as part of the specification. This steering gear is of the cam and lever type, and to ensure complete freedom throughout the entire range of movement a small amount of end float is provided on the rocker shaft. Underneath the lid of the steering box there are placed a number of thin shims, for adjustment of the rocker shaft end float in the event of wear occurring on the cam or on the pin extension of the rocker shaft which engages with the cam. Too much end float provides an excess of free movement on the steering wheel, whereas insufficient end float may cause binding at certain parts of the steering. The amount of end float which is desirable is between ·006 in. and ·010 in., and the adjustment should be made accordingly.

Replacing Steering Drop Arm Correctly

With regard to these three types of steering assemblies there is one important point which is common to all three, and that is to ensure that in the event of the drop arm being removed from the steering rocker shaft care should be taken to ensure that it is replaced in its original position. In those models which have the orthodox suspension the extent of the steering lock is controlled by stops which are fixed to the end of the axle beam, and against which the stub axles make contact. If the steering drop arm is replaced on the rocker shaft incorrectly it is more than likely that there will be a large lock on one side of the centre of the turning circle and a short lock on the other side. This will mean that on one lock the stop is actually occurring inside the steering box, and apart from the difficulty of being unable to obtain adequate steering owing to a short lock, there is also the possibility of damage occurring to the steering gear.

On the models which have independent suspension the steering stops are obtained by setscrews and locknuts which are screwed into the vertical brackets which carry the stub axle. These stops are therefore adjustable, and should be set in such a fashion that there should be a little further movement in the steering box by the time the steering stops have come into action.

THERMAL CHASSIS LUBRICATION

The steering assembly, with the exception of the steering box itself, on the 12-h.p. models with independent suspension, is lubricated by an automatic system of lubrication described as the "Bijur" automatic lubrication system. This consists of an expansion chamber, and is supported by a bracket adjacent to the exhaust manifold. The chamber is filled with oil from a gravity feed tank, and the heat of the engine causes the oil in the expansion chamber to expand and pressure is therefore created through the pipe-lines leading from the outlet valve of the chamber to the various steering points which require lubrication. This cycle of operation is carried out automatically each time the engine reaches its normal temperature and then cools down, but the efficiency of this lubrication depends upon the system being correctly primed with oil.

Priming the System with Oil

It is therefore important that the priming is carried out properly, and the following is the correct method of carrying this out :

(1) Check the oil level in container.

(2) Disconnect pipe from the bottom end of the expansion chamber and plug this pipe to prevent oil loss from the container.

(3) Apply priming pump or gun to the bottom end of expansion chamber and force oil through the expansion chamber and along the pipe-lines.

(4) During this operation examine the system for heavy or rapid leakages due to either loose connections or broken pipes.

(5) Continue priming until oil is seen exuding from each and every point in the system.

Failure of Valves in Expansion Chamber

It is possible through the introduction of foreign matter for the valves in the expansion chamber to be put out of action, thereby affecting the efficiency of the system, but this may be corrected by disconnecting the pipes from each end of the expansion chamber and unscrewing the valves. The valves should be washed in petrol, and to ensure that the expansion chamber is clean it should be swilled out with petrol also. When replacing the valves it is important that the joints are airtight, and it is therefore recommended that a jointing compound should be used, such as "Hermatite." It is, of course, necessary to remember that when failure occurs at any point of the system satisfactory results can only be obtained on re-priming the system in accordance with the foregoing instructions.

The oils which are recommended for use with this thermal chassis lubrication system are: Essolube Gear Oil Medium, Patent Castrol XXL, Mobiloil BB or CW, and Golden Shell Extra Heavy.

REPLACING ROAD SPRINGS

The road springs at the rear of Standard cars have incorporated silentbloc bushes in the eyes at both ends. This necessitates a different procedure when fitting replacement springs, as it is important that the shackle bolts be not tightened until the weight of the car is on the spring, when the shackle bolts should be tightened up solidly. The spring deflection and extension is arranged for by torsional movement of the rubber in the silentbloc bush, and this rubber should move to the same extent radially from a given zero position. This zero position is determined by the position of the spring when the weight of the car is on it and before the shackle bolts are tightened. Neglect of this precaution may result in overloading the rubber in the silentbloc bush, and therefore reduce its working life.

SERVICING LANCHESTER CARS

REAR AXLES, BRAKING SYSTEM, FRONT SUSPENSION, AND STEERING GEAR

By A. SQUILLARIO

THE REAR AXLE

Lanchester 10-h.p., 11-h.p., and 14-h.p.

FIG. 2 is an illustration of the section of a rear axle as fitted to these models.

To dismantle, remove the nuts holding the axle tubes to the axle casing and knock off the tubes complete with hubs and axle-driving shafts. It will be noted that the axle-driving shafts are splined at both ends and are a push fit in the differential but are secured to the hubs by nuts. In service these nuts should have periodical attention, as it is essential that they be kept perfectly tight.

The top cover of the case is then removed together with the nuts securing the bearing caps. Draw the caps of the studs and lift out the differential and worm-wheel assembly.

Remove the nut from the coupling flange also, the nuts holding the worm-shaft covers. Remove flanges and draw out worm shaft complete from the front end.

Assembly

The worm shaft is located by the front ball race, which is of the deep-track type, taking thrust as well as journal load. No adjustment is required or provided, the adjusting washer being standard.

The adjustment of the worm wheel is by means of sleeves (see Fig. 2). In fitting a new worm wheel, straps are placed over the axle-tube studs and tightened or let

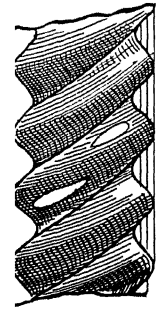


Fig. 1 (*Right*).—How to test accuracy of assembly (Lanchester 10-h.p., 11-h.p., and 14-h.p.)

Coat the worm with marking black, and bolt up in position. Two adjacent worm-wheel teeth have an indelible marking put on them to show where the worm must bear. On the worm being slowly rotated by hand, it can be at once seen if the assembly is correct.

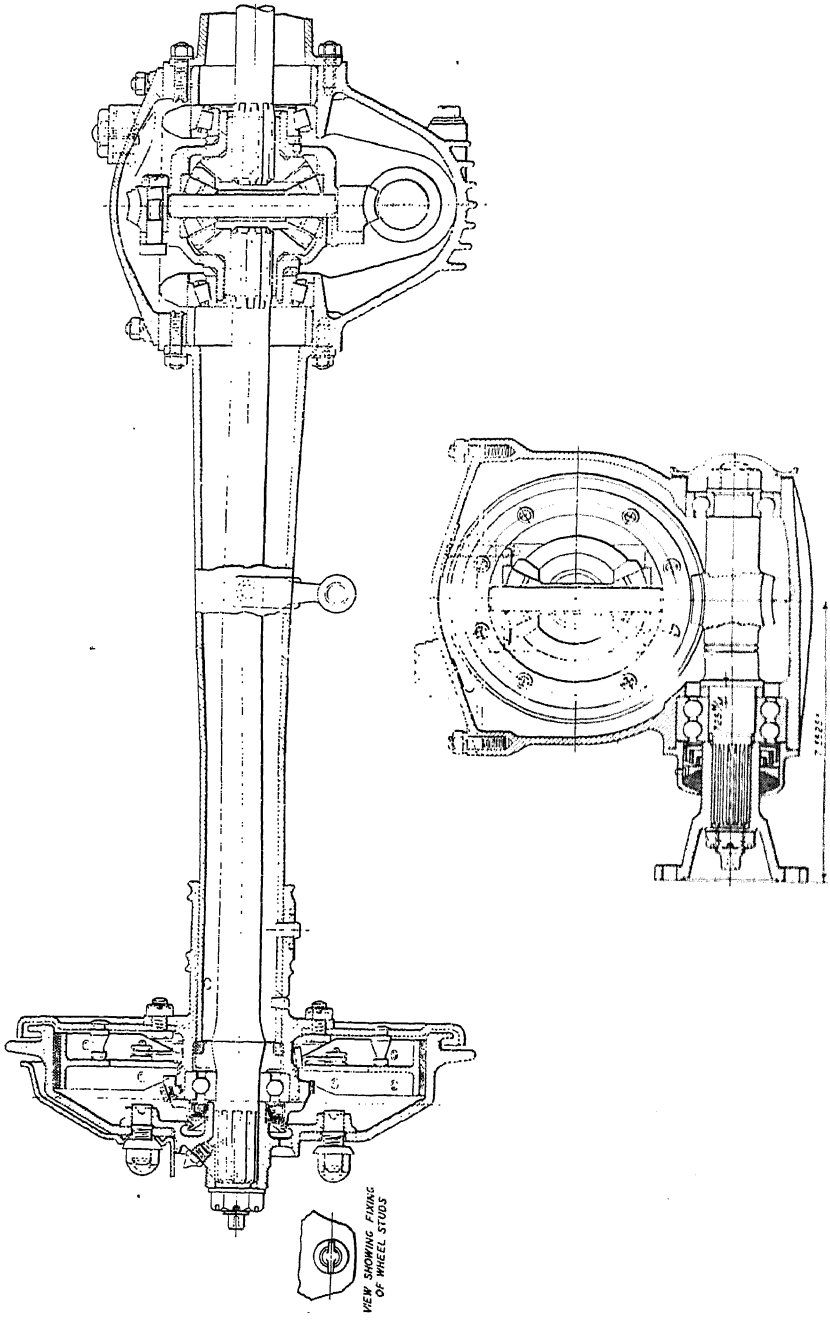


Fig. 2.—REAR AXLE ON LANCHESTER 10-H.P., 11-H.P., AND 14-H.P.

off until the worm wheel is correctly positioned according to marking, as shown in Fig. 1. The amount of sleeve then projecting beyond the joint face is then measured and the sleeves adjusted until the ends are just flush with the joint face.

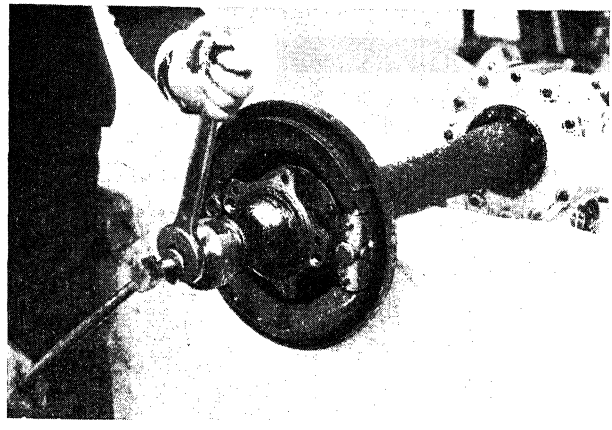


Fig. 3.—USE OF THE HUB EXTRACTOR

Lanchester 18-h.p.

On the axle fitted to this model the near side axle tube is attached to the main cover.

The use of a hub extractor is necessary, as shown in Fig. 3. Remove the nuts holding the axle tubes to the casing and draw the tubes off the studs. Remove setscrews securing the cover plate on the near side of the axle case.

Draw out the differential case housing on the offside of the axle casing, using special extractor as shown in Fig. 4. This operation will give sufficient clearance to enable the differential and worm-wheel assembly to be tilted so that it can be withdrawn through the aperture on the near side, after the cover plate has been eased from the casing, to which it is spigoted. Do not attempt to force out the assembly, as damage may be caused to the teeth of the worm wheel.



Fig. 4.—LANCHESTER 18-H.P.

Drawing, by means of extractor, differential housing on Lanchester 18-h.p. axle case on the off side.

To dismantle the worm wheel and differential assembly, remove the locknut from the Timken races and draw off the large cover plate. Remember to note the order of assembly of these races, as they must be reassembled paired as before. Remove bolts from the worm wheel and differential case and

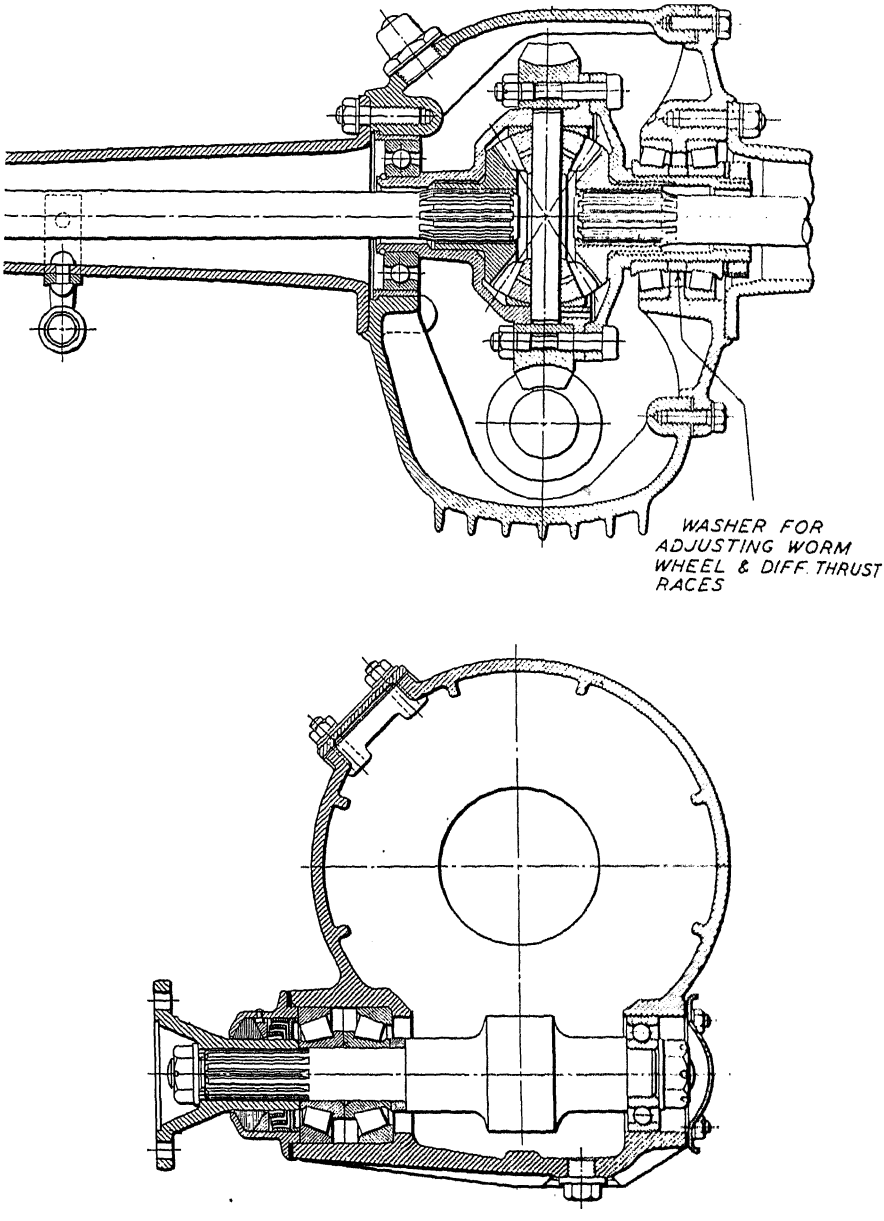


Fig. 5.—LANCHESTER 18-H.P. REAR AXLE ARRANGEMENT

Showing the washer, the thickness of which is varied for adjustment of the differential and the worm-wheel unit.

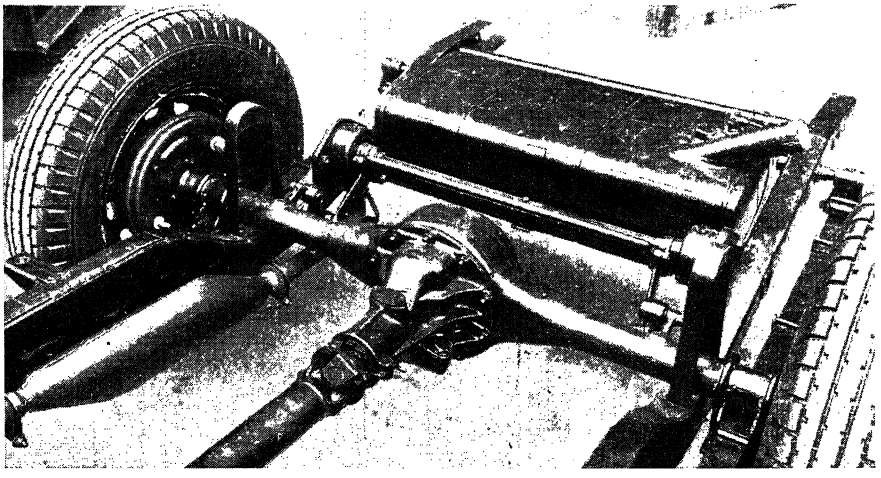


Fig. 6.—LANCHESTER 14-H.P. REAR AXLE IN POSITION

part them. The differential pinions, pin, etc., can be taken out.

To remove the worm shaft, take off the nuts from the front and rear cover studs, and draw the driving jaw off the splines on the shaft, after removing the split pin and securing nut.

Assembly

Fit the worm shaft in the casing and assemble the differential and worm-wheel unit. The adjustment of the latter is controlled by the twin tapered roller bearings and is effected by varying the thickness of the washer between the two inner races. The assembly should revolve freely on the races without any lift after tightening up the locknut (see Fig. 5).

The order of dismantling may now be reversed ; but if any new parts have been fitted, the position of the worm wheel must be checked. The adjustment of the worm wheel is varied by means of shims between the axle casing and the large cover plate.

Examination of Parts

Worm and worm wheel should be carefully examined, and if the worm wheel is worn, it should be returned to the makers. It can then be re-cut and paired with the existing worm.

Particular attention should be given to felt washers, and it is advisable to fit new ones when assembling. After axle has been assembled and tested, examine worm shaft gland and all joints for leakage.

THE REAR AXLE AS FITTED TO LANCHESTER 14-H.P. DE LUXE

Adjustment is provided for the setting of both the crown wheel and pinion, but unless the assembly has been dismantled for any reason, no

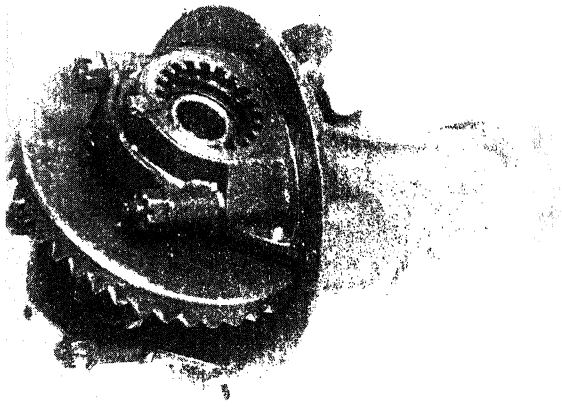


Fig. 7.—E.N.V. REAR AXLE, LANCHESTER 14-H.P. DE LUXE

adjustment should be necessary.

To Dismantle

Remove split pins and nuts which secure differential journal bearing caps. After removing bearing caps, the differential assembly can be withdrawn complete, and can be dismantled in the usual way by removing differential case bolts which secure the crown wheel.

Remove split pin and nut which secure the coupling to the front end of the pinion shaft, then press out the pinion through the bearings. The thrust bearing and the outer ring of the roller bearing will remain in the housing. The thrust bearing can be pressed out after the adjuster ring at the front end has been removed. The outer ring of the roller bearing can be pressed out towards the rear of the casing. The thrust bearing inner adjusting ring can then be screwed out if required.

To Reassemble

Screw thrust bearing inner adjusting ring into position in the housing, and press in outer ring of roller bearing, being careful to place the lip of this ring towards the front end. Insert thrust bearing and $\frac{1}{8}$-in. washer, and screw in outer thrust bearing adjuster ring.

After placing pinion-head washer in position, press the inner ring of the roller bearing on to the pinion stem. Place bearing

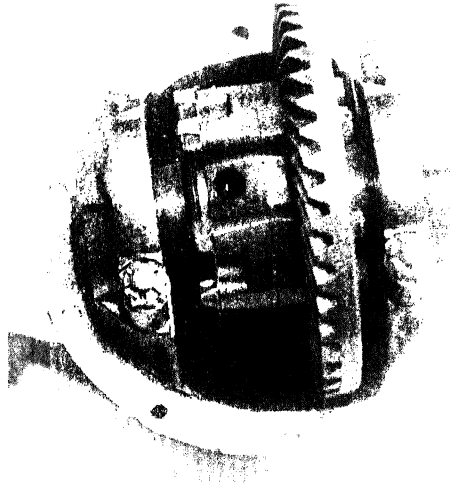


Fig. 8.—E.N.V. REAR AXLE, 14 H.P. DE LUXE

distance piece on the pinion and press the pinion into the housing, making sure that the $\frac{1}{8}$-in. washer mentioned previously is in position.

After reassembling differential case and crown wheel, check the latter for running true. The wheel should not run out more than 0·003 in. when measured on its back face and at its greatest diameter. Place assembly in position and tighten bearing caps sufficiently to grip the side adjuster ring nuts, but not tight enough to lock them.

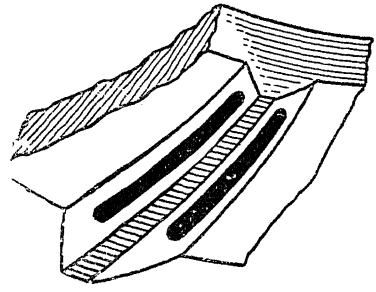


Fig. 9.—BEARING REQUIRED (UNDER NORMAL CIRCUMSTANCES) FOR 14-H.P. LANCHESTER DE LUXE REAR AXLE

When meshing the gears, care must be taken to engage the teeth in the position marked on the crown wheel and pinion. To adjust the gears to their best running position, the teeth should first be painted with a mixture of red lead and oil or some other suitable marking. The correct tooth contact extends from the small end of the tooth to approximately two-thirds of its length, and from the top of the tooth to its root (see Fig. 9), and is obtained by moving the position of the pinion by means of the two adjusting-ring nuts.

A thin-line contact at the root of the teeth of the crown wheel should be avoided. When the pinion is adjusted away from the crown wheel, the bearing contact will move away from the root of the crown-wheel teeth, and vice versa. The correct backlash between the gear teeth is from 0·004 to 0·006 in., when measured at the outside diameter of the crown wheel, and is obtained by adjusting the two adjuster-ring nuts at the side of the differential assembly. The adjustment of the pinion must on no account be moved to alter backlash.

After the gears have been set correctly, tighten the bearing-cap nuts and insert split pins. Fit locking pieces to pinion adjuster-ring nuts.

THE BRAKING SYSTEM

The early type 10-h.p. and 15/18-h.p. were fitted with hydraulic-operated brakes, the latter model being servo-assisted.

Adjustment

Adjustment is simple, the only tool necessary being a $\frac{3}{8}$-in. spanner. Jack up offside front wheel and screw the two adjuster nuts outwards until each brake shoe is just touching the brake drums. Now screw adjuster nuts inwards slightly until the wheel is just able to rotate perfectly freely. Repeat this operation for remaining wheels in following order: nearside front, offside rear, and nearside rear. When the foot-brake is fully applied, the minimum safe clearance between the pedal and

the floorboard is 1½ in. When the clearance is reduced to more than this amount, further adjustment is necessary.

To bleed the System

The process of bleeding the system should only be necessary after some part of the braking gear has been dismantled or the level of fluid in the supply tank has been allowed to fall so low that air has entered the pipes. Remove bleeder screw from offside front wheel and screw in bleeder tube. Allow the end of the tube to hang in a glass container. The supply tank should be kept about three-quarters full during the operation. Unscrew bleed valve one half-turn and push down brake pedal slowly and allow to return to the "off" position. Repeat this a number of times until all the air is expelled from the system, which is ascertained when bubbles cease to appear in the glass container. With the pedal still pressed down, tighten bleed valve. Repeat on the other wheels in the following order: nearside front wheel, offside rear wheel, and nearside rear wheel. Use only official-type hydraulic brake oil as recommended by the makers.

The Girling Mechanical Brake

Fig. 10 illustrates the layout of this type of system. Adjustment is very simple and is effected by turning adjuster nut. Do not touch split-pinned cone-housing nuts, as it is intended that the housing should be allowed to float to a limited extent.

Accurate adjustment can be made without jacking up the wheels by rotating the adjuster nut until it will turn no more. (The shoes are then up against the drum.) Turn the nut back until the flats of the cone are felt to be in engagement with the brake-shoe pivots. At this point the required clearance of 0·015 in. on each shoe is obtained.

The Bendix Brake as fitted to Lanchester 14-h.p. de Luxe

Wear is taken up by centralising the two shoes in the drum by means of the eccentric centraliser and expanding them in the drum by means of the shoe adjustment (see section on Bendix brakes, Vol. I).

Slack off centraliser nut on the outside of the backing plate and turn shoe adjuster in a clockwise direction as far as it will go. Tighten centraliser nut and slack off shoe adjuster until wheel is just free.

When shoes need relining, the brake shoes should be removed and returned to the makers, when replacement shoes will be supplied. The desired clearance of shoe in drum is 0·008 in.

FRONT SUSPENSION OF LANCHESTER 14-H.P. DE LUXE

The André-Girling independent front-wheel suspension employs a system of linked arms which ensures that each front wheel follows independently the road inequalities. It is possible to drive over uneven road surfaces with the maximum of riding comfort and road-holding.

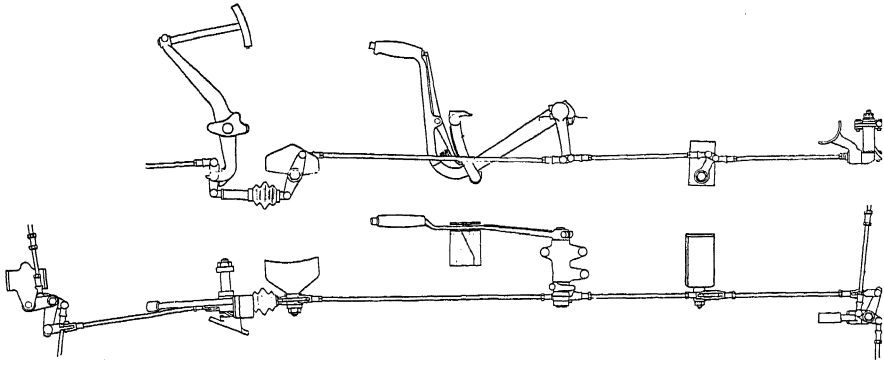


Fig. 10.—LAYOUT OF GIRLING BRAKING SYSTEM ON LANCHESTER 10-H.P., 18-H.P. (1935 ONWARDS), 11-H.P., AND 14-H.P. ROADRIDER

To remove the large oil springs, the front of the car should be jacked up and supports placed under the frame members. Remove the wheels and place a jack under one of the transverse links in its extended position. The jack should be placed near the inner end of the link and the centre bolt removed, allowing the weight to be taken by the jack until the springs can be removed.

Inspect the bolts holding the silentbloc bushes and the spherical joints at the bottom of the pedestal. These bolts should all be tight and not be allowed to float in the bush.

The toe-in of the front wheels should be $\frac{1}{8}$ in. minimum to $\frac{3}{16}$ in. maximum, and it is imperative that these figures are strictly adhered to. Adjustment of toe-in is as follows :

Slacken locknuts at the outer ends of both track rods and remove ball pins from stub-axle steering arms.

Set wheels dead parallel. This may be done by measuring from frame to inner edge of wheel rim.

Adjust both rods until the combined toe-in is $\frac{1}{8}$ in. and not greater than $\frac{3}{16}$ in. and replace ball pins and split pins, and tighten locknuts.

When this adjustment is made, it is important to check the position of the steering-pivot lever. With the front wheels in central position, the lever should be dead parallel with the wheels.

Camber

Desired angle is $1\frac{1}{2}°$. If the wear on either of the front tyres is found to be uneven, or wearing more on the outside than on the inside, a careful check should be made of the camber of the wheel concerned. This is adjustable by means of the short transverse link at the top of the pedestal. Before removing either of the bolts at the ends of this link for adjustment, the front of the frame should be supported by a jack. One bolt can then

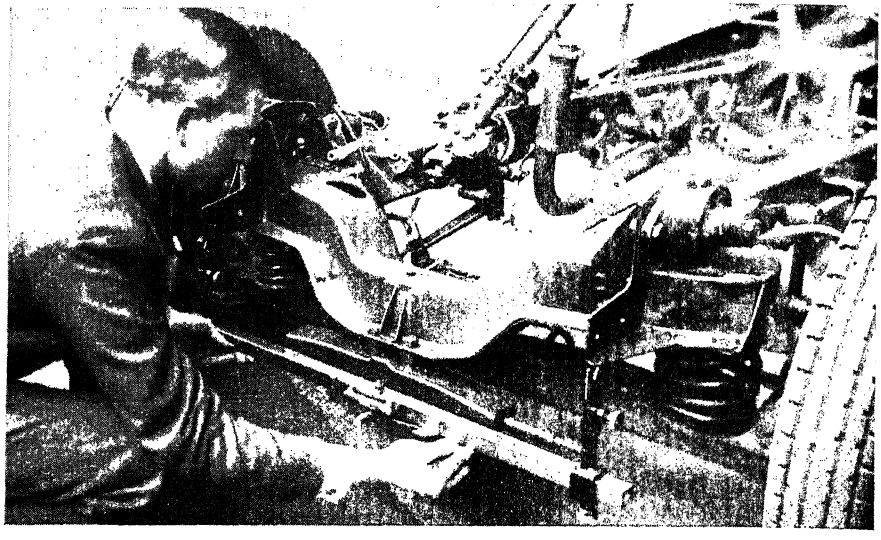


Fig. 11.—TO CHECK CAMBER

First ascertain whether car is perfectly level. The picture shows typical spirit-level gauge with two sliding arms. Adjust pressure in tyres until spirit-level reads centrally.

be removed and the link adjusted to suit. It is important that the frame remains in its normal unloaded position, and it should not, therefore, be lifted when jacking up.

Both settings for track and camber are given with the cars in an unloaded position.

CAM AND LEVER STEERING

The cam-and-lever type steering as fitted to 1933–5 10-h.p. and 1933–4 18-h.p. models is simple in construction and requires little attention.

The cam and mainshaft are mounted on ball bearings which take the thrust from the rocker shaft, and shims are introduced under each end cover so that the cam is mounted centrally in the box. If the gear is dismantled for cleaning or inspection a careful note of the number of shims at each end should be made. On reassembling this shaft should "spin" with the fingers, but there should be absolutely no end play. If necessary to remove shims, remove them equally from both ends if possible.

The Rocker Shaft

The motion of the steering wheel is transmitted to the road wheels through the cam, and the roller fitted into the rocker shaft lever, and in

time, wear (as shown by "lost motion" between the steering wheel and the drop arm) may possibly become apparent. This may be rectified by removing one or more of the shims underneath the side cover plate covering the rocker shaft lever. If too many shims are removed the gear will become stiff on full lock and this must not be permitted.

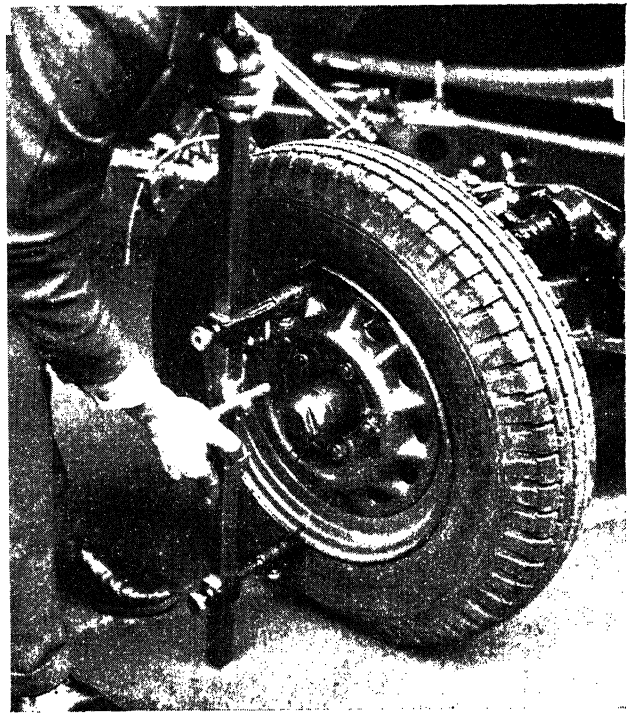


Fig. 12.—TOOL IN USE TO CHECK CAMBER ANGLE

The roller runs in a hardened steel bush, and these two parts must always be a very close fit, being only just sufficiently free to revolve. In some models the roller is replaced by a conical pin which does not revolve.

All adjustments to the steering gear should be carried out with the drag link disconnected.

Removal of the Drop Arm

The drop arm is attached to the rocker shaft by means of a splined taper and secured by a slotted nut. Lugs are provided on the drop arm in order to facilitate removal by means of a drawer, but if this means is not available and it is necessary to use a hammer, *the side cover plate must be removed first,* and the shaft should be driven through the drop arm, so that the reaction from the blow is taken on the main casing instead of on the hardened steel cam and roller.

Replacing the Drop Arm

When replacing the drop arm, care must be taken to refit it to the correct spline to give an equal lock. If the parts were not marked before dismantling, attach the drop arm to the drag link by its ball pin, and after

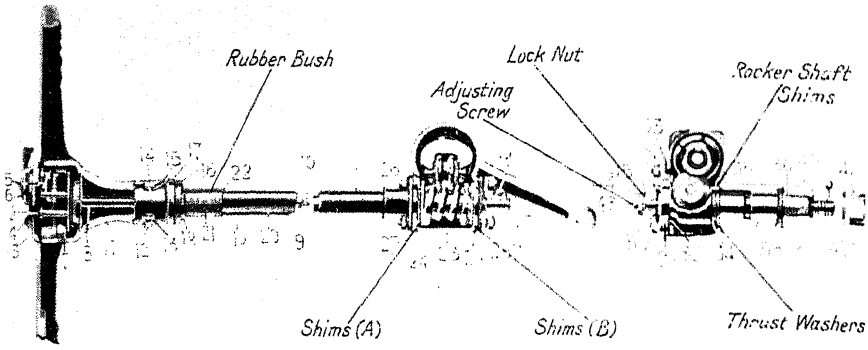


Fig. 13.—STEERING GEAR, 14-H.P. LANCHESTER DE LUXE

The shims (*A*) are for cam-bearing adjustment. Shims (*B*) should not be interfered with. The adjusting screw is for adjusting end play of rocker shaft, while the rocker-shaft shims, situated between the thrust washers, are for taking up slack at drop arm.

placing the road wheels in the "straight ahead" position, turn the steering wheel as far as it will go on the left lock, then bring it back three-sevenths of its full motion and mount the drop arm on the spindle in this position, taking care to ensure that the slotted nut is tightened right home and the nut securely split pinned. The front axle should then be jacked up and a test made to ensure that there is full lock on both sides and that the stub axles come properly up against the stops on the front axle beam.

THE DOUBLE-ROLLER TYPE STEERING AS FITTED TO LANCHESTER 14-H.P. DE LUXE

Cam Bearing Adjustment

Referring to Fig. 13, it will be seen that there are a number of shims (*A*) between the steering-box casting and the column support. The end play on the cam between the bearings can thus be removed by taking out one or more of these shims. This allows the thrust cone carried by the column support to enter farther into the steering box, and thus come closer to the cam.

Between the steering box and the bottom cover there are similar shims (*B*), but it is not necessary to disturb these, as they are, for the purpose of centring the cam, relative to the rocker shaft, and are correctly set upon assembly.

Adjustment of End Play of Rocker Shaft

Loosen locknut on back of cover plate and tighten adjusting screw until end play is removed. Do not forget to tighten locknut after adjustment.

The correct method of ascertaining the elimination of end play is to turn steering wheel on either full lock and turn back about one-eighth of a turn. The rocker shaft should rotate freely without any end play when the drop arm is held firmly at steering-box nose.

Adjustment of Engagement between Roller and Cam

Disconnect drag link and turn steering wheel to mid position. Shake drop arm to determine amount of slack, and if this is more than $\frac{1}{32}$ in., adjustment is necessary.

It will be seen in Fig. 13 that there are a number of shims between the thrust washers behind the rocker shaft. By removing one or more of these shims, the rocker shaft and roller will enter farther into the box, thus making close contact with the cam.

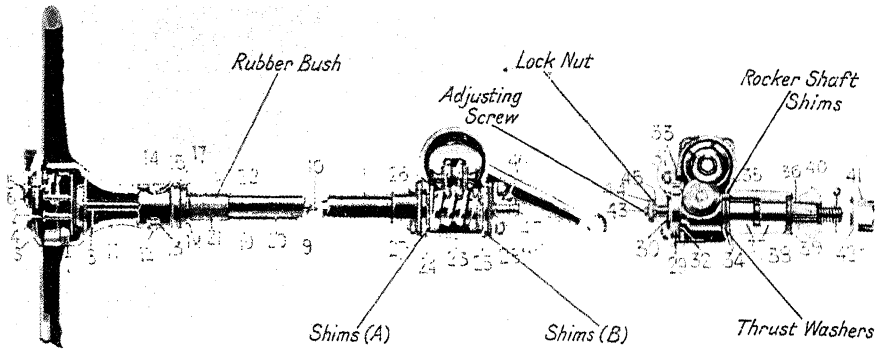


Fig. 13.—STEERING GEAR, 14-H.P. LANCHESTER DE LUXE

The shims (*A*) are for cam-bearing adjustment. Shims (*B*) should not be interfered with. The adjusting screw is for adjusting end play of rocker shaft, while the rocker-shaft shims, situated between the thrust washers, are for taking up slack at drop arm.

placing the road wheels in the " straight ahead " position, turn the steering wheel as far as it will go on the left lock, then bring it back three-sevenths of its full motion and mount the drop arm on the spindle in this position, taking care to ensure that the slotted nut is tightened right home and the nut securely split pinned. The front axle should then be jacked up and a test made to ensure that there is full lock on both sides and that the stub axles come properly up against the stops on the front axle beam.

THE DOUBLE-ROLLER TYPE STEERING AS FITTED TO LANCHESTER 14-H.P. DE LUXE

Cam Bearing Adjustment

Referring to Fig. 13, it will be seen that there are a number of shims (*A*) between the steering-box casting and the column support. The end play on the cam between the bearings can thus be removed by taking out one or more of these shims. This allows the thrust cone carried by the column support to enter farther into the steering box, and thus come closer to the cam.

Between the steering box and the bottom cover there are similar shims (*B*), but it is not necessary to disturb these, as they are, for the purpose of centring the cam, relative to the rocker shaft, and are correctly set upon assembly.

Adjustment of End Play of Rocker Shaft

Loosen locknut on back of cover plate and tighten adjusting screw until end play is removed. Do not forget to tighten locknut after adjustment.

The correct method of ascertaining the elimination of end play is to turn steering wheel on either full lock and turn back about one-eighth of a turn. The rocker shaft should rotate freely without any end play when the drop arm is held firmly at steering-box nose.

Adjustment of Engagement between Roller and Cam

Disconnect drag link and turn steering wheel to mid position. Shake drop arm to determine amount of slack, and if this is more than $\frac{1}{32}$ in., adjustment is necessary.

It will be seen in Fig. 13 that there are a number of shims between the thrust washers behind the rocker shaft. By removing one or more of these shims, the rocker shaft and roller will enter farther into the box, thus making close contact with the cam.

SERVICING VAUXHALL 10-H.P. AND 25-H.P. INDEPENDENT SUSPENSION SYSTEMS

By K. SYLVESTER

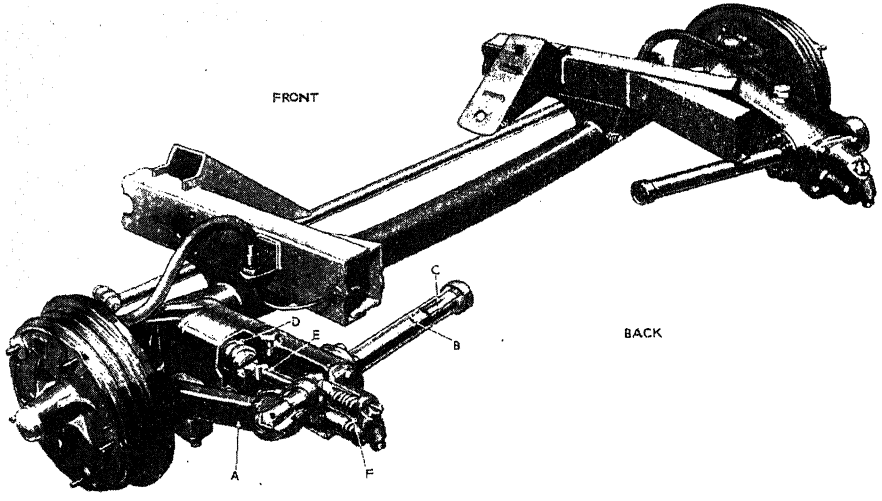


Fig. 1.—CUT-AWAY VIEW OF 10-H.P. MODEL FRONT SUSPENSION UNIT

IN order to be able to diagnose faults correctly it is essential for the mechanic to have a clear idea as to "the why and the wherefore" of the system which is employed on the Vauxhall 10-h.p. and 25-h.p. models.

Why Independent Suspension ?

The primary aim of the designers was to obtain a very soft ride without the consequent disadvantages of instability and inaccurate steering. All the difficulties with steering geometry which are encountered in a normal suspension, due to the fact that the steering connections are partly mounted on the sprung chassis and partly on the unsprung front axle assembly, are overcome. In the case of the Vauxhall the whole of the steering mechanism is mounted solely on the chassis, and no unwanted relative movement between the connections can therefore take place.

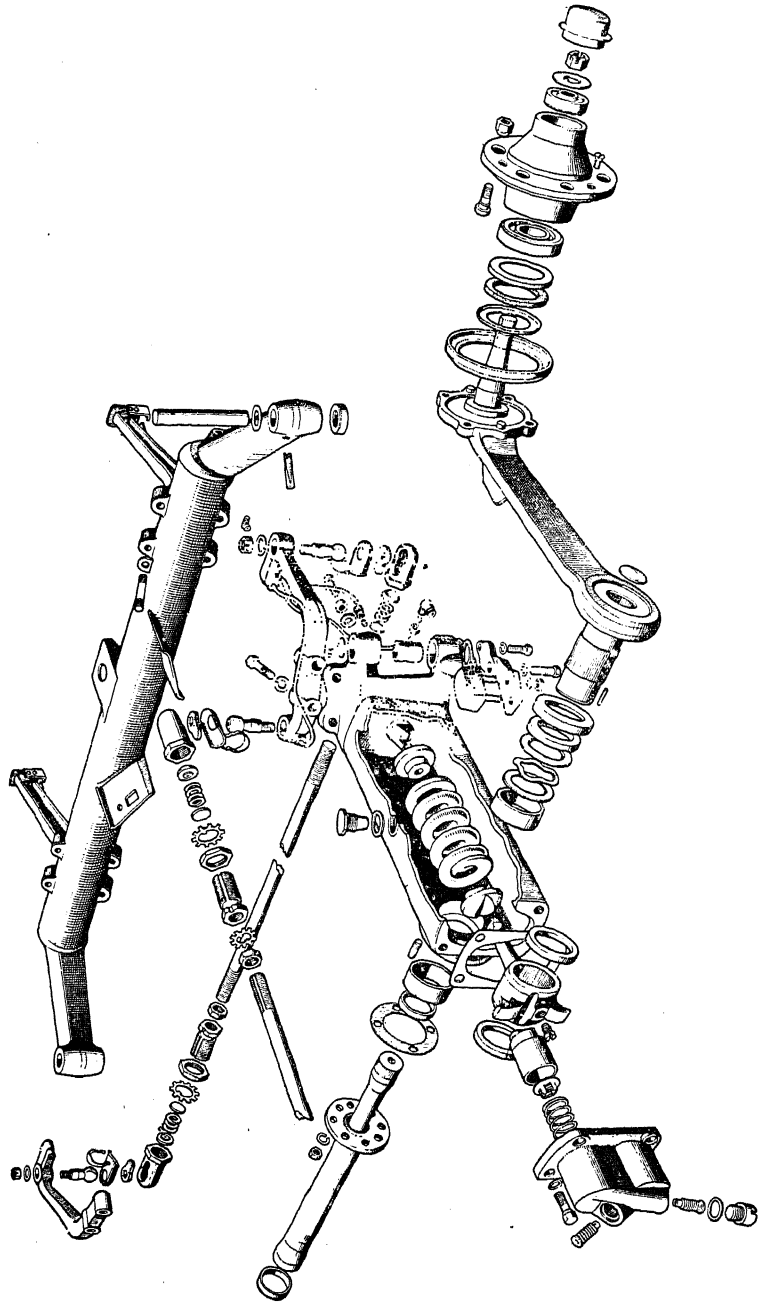


Fig. 2.—FRONT AXLE BEAM AND INDEPENDENT SUSPENSION DETAILS, 25-H.P. MODEL

In order to obtain the very soft springing which was aimed at, some means had to be found of stiffening up the suspension for large deflections, otherwise the total movement would be excessive. The apparently obvious method of using a very soft spring and then incorporating buffers to limit its travel would be a poor engineering job, and a more scientific method has been developed. Instead of using a soft spring and limiting its movement with buffers, a hard spring (torsion bar) has been used, coupled with a compensating toggle spring so arranged as to assist the wheels to deflect the torsion bar throughout the range covered by normal deflections. However, the effectiveness of this compensating spring diminishes with deflection and thus a progressive springing is obtained.

The result is a system of suspension which is extremely soft and flexible on the " sweet spot," but which progressively stiffens up as the deflection increases ; in other words, a soft suspension for normal driving which tends to stiffen up considerably at higher speeds—when deflections are greater—and which has a resistance to roll which could not possibly be provided with a normal soft suspension.

Explanation of System

The following explanation should be read in conjunction with Fig. 1. The wheel is carried on the wheel carrier-arm (*A*). The other end of the wheel carrier-arm is supported by means of a splined sleeve mounted on needle roller bearings in a steel housing, which is hinged by means of a pivot pin to a cross-member which takes the place of the front axle ; this cross-member is, of course, rigidly bolted to the chassis.

External splines at one end of the torsion bar (*C*) engage with internal splines in the sleeve, which is integral with the rear end of the wheel carrier-arm. The other end of the torsion bar is splined to the torsion tube (*B*), the flanged end of which is bolted to the suspension housing.

Dealing now with that part of the suspension which has already been described, and ignoring the other mechanism, it can be seen that upward movement of the wheel will turn the wheel carrier-arm (*A*) in a clockwise direction. As the wheel carrier-arm is attached to the torsion bar this will also be twisted in a clockwise direction, and this twist must be taken up by the bar and tube. The reason for using a bar and a tube is to obtain a great length of " spring " in as compact a space as possible. As so far described this could be used as a normal independent suspension, but in order to obtain the progressive springing which is essential to a comfortable *and* stable ride the compensating spring (*D*) is incorporated. The toggle arm (*E*) is attached by means of a grub screw to the outer diameter of the sleeve previously mentioned, and the knife edge is loaded by a short but very stiff coil spring (*D*) under compression. On the opposite end of the toggle are feet which engage with the pistons of the double-acting shock absorber (*F*), which is bolted to the rear end of the housing.

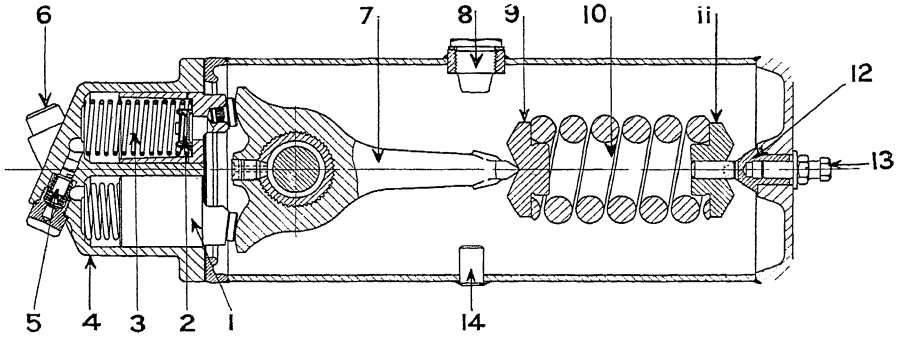


Fig. 3.—SECTIONED VIEW OF FRONT SUSPENSION UNIT

1. Shock absorber piston.
2. Inlet valve.
3. Contact spring.
4. Shock absorber housing.
5. Metering valve (controlling upward movement of wheel carrier arm).
6. Rebound valve retaining cap.
7. Compensating spring—control lever.
8. Filler plug and upper stop.
9. Compensating spring rear seat.
10. Compensating spring.
11. Compensating spring front seat.
12. Knife edge.
13. Lock stop.
14. Lower control lever stop.

Referring to the drawing, Fig. 3, it will be seen that movement of the wheel carrier-arm moves the compensating lever, the feet of which bear against hardened-steel pads on the shock-absorber pistons and thus cause the pistons to move. The pistons are pushed up into the cylinders by these feet and are returned by the coil springs (3). The fluid is always passed from one cylinder to the other, and in so doing it is forced through the metering valves (5) and (6). These valves consist of a " slow leak " hole through which the fluid normally passes, and a spring-loaded valve through which excess fluid passes under severe deflection.

Maintenance Attention

As the whole of the mechanism is enclosed in an oil bath, the only attention required is to keep the oil bath full of shock-absorber oil. It is most important to use only an approved shock-absorber oil, as ordinary lubricating oil would upset the calibration of the suspension entirely.

Setting of Torsion Bars

Torsion bars have to be set so that the car will be riding on the " sweet spot " when carrying a normal load, and for this purpose an adjustment in the form of a vernier is provided.

The first thing to bear in mind with one of these torsion bars is that the minutest scratch or dent in the bar will almost certainly be a point of fatigue fracture sometime during the life of the bar. When handling these bars, therefore, it is essential to be extremely careful not to bump them in any way. The bar itself must not even be touched by hand, as perspiration is sufficient to set up oxidation of the bar, which will weaken it considerably.

To Remove Tube and Bar Assembly for Resetting

Obtain a receptacle to receive the shock-absorber oil, which may be drained by taking out the lower setscrews attaching the shock-absorber unit to the rear face of the housing. Raise the front of the car by means of a jack until the wheels hang clear of the ground. Remove the nuts and washers securing the flange of the torsion tube to the housing. In order to remove the tube and bar assembly for resetting, the position of the wheel carrier-arm at which there is no torsion must be found. To find this position, lower the car slowly until the position is obtained when the torsion bar and tube is loose.

The best way to do this is for one man to lower the car while another watches the flange on the studs *with a good light*. The moment the tube passes from torsion in one direction to torsion in the other, i.e. the free point, the flange can *just* be seen to move on the studs. In this position the torsion tube can be pulled out quite easily. *DO NOT USE FORCE*. If it will not come out easily, it indicates that the free point has not been found.

The splines on the bar and the holes in the flange are so arranged that a vernier coupling is obtained ; turning the tube round one hole will actually have the effect of moving the position of the wheel carrier-arm slightly less than 1°.

Setting the Bar and Tube

The bar and tube must be turned in the direction in which the wheel carrier arm is to be moved in order to produce the desired result. In other words, if the left-hand side of the car is to be raised, the wheel carrier-arm must be turned in a clockwise direction as viewed from the torsion-tube side—that is, the side from which the man on the job will view it—and the torsion tube must therefore be turned in a clockwise direction. To raise this side of the car, therefore, remove the torsion tube, turn it round nearly one complete stud hole, engage the splines and then raise the car *slightly* so that the flange can be pushed over the studs.

Correct Riding Height of Car

Lower the car slightly until some weight is taken by the wheels and then replace and tighten up the flange nuts. It is most important to set these torsion bars so that the car rides at the correct height. In the case of the 25-h.p. model, this is when the dimension as shown in Fig. 4 is 4 in. plus or minus $\frac{1}{8}$ in. with two people, or the equivalent ballast, in the front seats. On the 10-h.p. model the dimension is taken vertically from the lower edge of the brake-flange plate to the head of the front bolt attaching the steering arm to the steering knuckle. This dimension should be $1\frac{1}{4}$ in. plus or minus $\frac{5}{64}$ in. with two people in the front seats.

It is most important to have these dimensions correct, as otherwise

the car will not normally be riding on the "sweet spot" and the suspension will therefore be hard.

To Replace a Broken Torsion Bar

If the bar of the assembly to be replaced has broken, the tube should be withdrawn and the remaining portion of the bar extracted, if necessary, by removing the expansion plug in the wheel carrier-arm and tapping the shaft out gently, using a brass drift, afterwards fitting a new expansion plug. The weight of the car, in the absence of resistance from the torsion members due to the breakage, will have moved the wheel to its extreme lift position so that the toggle butts against the combined stop and filler plug.

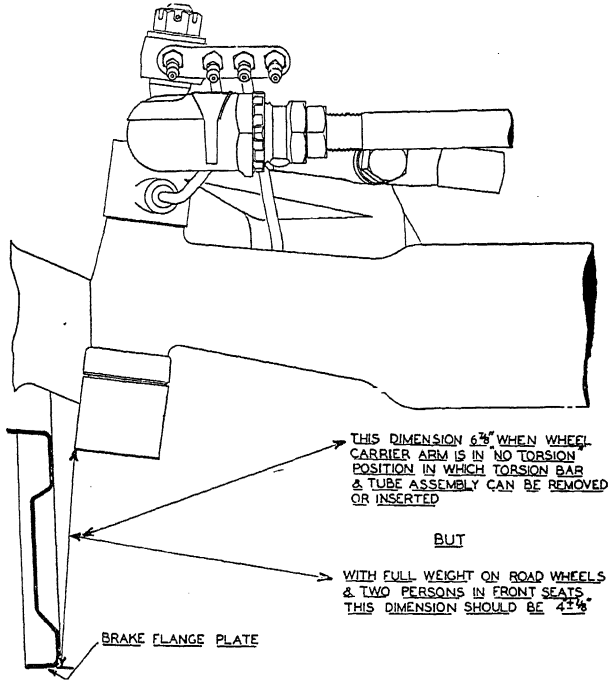


Fig. 4.—How dimensions are measured when checking for height adjustment (25-h.p. model)

The wheel must, therefore, be pushed down with the aid of an assistant so that the toggle is brought over "dead centre" against the pressure of the compensating spring, when it will rest on the lower stop of the housing. The new torsion bar and tube assembly can then be fitted in the normal way.

To Dismantle Suspension Unit

The following description applies to the 25-h.p. model and should be read in conjunction with Fig. 2. The system used on the 10-h.p. model is almost identical, and a separate description is not therefore warranted.

To dismantle the suspension unit, it must be removed from the chassis. It is, however, advisable to remove the torsion bar and tube assembly first, as the weight of the car can then be used to bring the wheel carrier-

arm to the " no torsion " position in the normal way so that the tube and shaft can be withdrawn.

It is also advisable to remove the brake assembly, which is attached by four setscrews to the wheel carrier-arm. The assembly can then be laid on one side, and in this way there is no need to disturb the hydraulic braking system.

The front suspension unit can now be detached from the kingpin in the normal way.

Remove the shock-absorber assembly by taking out the four setscrews which hold it in position. Remove the grub-screw which secures the control lever to the carrier-arm journal after clearing the punch marks which lock it in position.

Press the wheel carrier-arm out of the housing, taking great care to catch the needle rollers, which will probably fall out during this operation.

Draw out the control lever with its side washers and then withdraw the remaining parts in the following order :

Knife-edge seat.

Spring.

Lower knife-edge seat.

The inner knife edge should not be removed unless it is absolutely essential, as it has to be replaced exactly parallel with the axis of the wheel carrier-arm, and it is by no means easy to do this with the necessary accuracy. Remove the oil-seal retainer from the carrier bearing outer end, and press out the outer races. This completes the dismantling of the unit.

To Reassemble Suspension Unit

Press in the needle roller outer races. Press a new oil seal into the counterbore of the housing and crimp the lip of the cap into the groove on the outside of the boss of the housing. If the inner knife edge has been removed, this must now be pressed into position, and it is absolutely essential that it should be parallel with the carrier-arm journal to within a quarter of a degree. Now place the housing vertically in a vice and lower the following parts carefully into position :

Front knife-edge seat.

Spring.

Rear knife-edge seat.

Allow these parts to rest on the bottom side of the housing (away from the filler plug), place the control lever and spacers into the housing, and check the side clearance. This should be within the limits of ·002 in. to ·007 in., and in order to obtain the requisite clearance, spacers of varying thicknesses can be obtained from the manufacturers. The part number of the normal spacer is 1034054, the thick spacer is 1034053, and the thin spacer is 1034055.

Having placed the control lever into the housing with the thickened

spline towards the filler-plug side, lay the 43 needle rollers in the outer race, keeping them in position by means of thick grease.

Enter the wheel carrier-arm so that the thickened spline on the journal lines up with the thickened spline in the control lever. Some difficulty will probably be experienced in entering the arm without disturbing any of the needle rollers, but this operation is quite possible with patience.

Press the carrier-arm into position, secure it with the grub-screw, and lock the screw by means of punch marks. Drop the 41 needle rollers of the opposite journal into position, followed by the spacer, and refit the shock absorber. The unit is now ready for refitting to the chassis, after which the torsion bar and tube assembly can be fitted and adjusted for correct height as previously described.

The above instructions apply also to the 10-h.p. model, except that there are 63 needle rollers in the outer wheel carrier-arm bearing and 52 in the inner bearing. The part numbers of the control-lever spacers are as follows :

Outer spacer . . .	1037054
Inner spacer—thin . .	1037266
Inner spacer—thick . .	1037267

Front-wheel Alignment—Important

The front-wheel alignment of the Vauxhall 10-h.p. and 25-h.p. models differs from standard practice in that the wheels must be set parallel (no toe-in) when in the straight-ahead position. When carrying out this adjustment, two people, or their equivalent in ballast, must be in the front seats of the car. as the setting varies considerably with load.

Springing too Hard

The most likely cause of this is that the torsion bars are so set that the car is not normally riding on the " sweet spot." It must be appreciated that the springing provided by the torsion bar and tube is very stiff, and unless this is correctly modified by the compensating spring, the ride is bound to be hard. All that is necessary is to check up the measurements as given previously, and to reset the torsion bars if necessary.

Another possibility is that the housings have been allowed to run short of fluid, so that the shock absorbers may work on air for the first part of the stroke and then suddenly come up against the fluid. This causes springing that is harsh rather than hard.

It should also be ascertained that the correct fluid is used. Attempts are sometimes made to stiffen up the suspension by adding a small quantity of engine oil, but this practice is extremely bad, and if the fluid is suspected, it should be drained out and the housings refilled with an approved brand.

Springing too Soft

In the case of the 25-h.p. model, this may quite possibly be an impression rather than a fact. Drivers coming off a car of normal suspension on to the Vauxhall " 25 " are inclined to have a feeling of insecurity during the first few hundred miles, due to its extreme softness. However, if they can be persuaded to retain the suspension as it is for some five hundred miles, they usually become accustomed to this false feeling of insecurity. It is most undesirable to stiffen up the springing, as its whole beauty lies in the softness and absence of pitch. However, if the springing really is soft, the following points should be checked over :

The seating of the inlet valve which is located inside the piston : it is possible that a particle of grit has got on the seating of this valve and so prevents it functioning correctly.

A broken shock-absorber spring will, of course, put that particular piston out of action, but this is usually accompanied by noise, and can be detected in that way. The only other possibility is that a piston may be stuck in its cylinder, and in this case the remedy is obvious.

If all the above points are found to be in order, then the springing is as designed by the manufacturers and should not be altered.

There is, however, a method of stiffening up which, although not recommended by the manufacturers, does function tolerably well.

In the case of the 25-h.p. model, the rebound valve is of a more severe nature than that of the bump valve. If, therefore, a rebound valve is inserted in place of the bump valve, it will have the effect of stiffening up the suspension considerably. The rebound valve can be distinguished from the bump valve by the fact that the spring of the former is cadmium-plated, and that of the latter copper-plated. The bump valve is that which is retained by the lower plug, and the rebound is retained by the upper plug.

The above remarks apply to the 10-h.p. model also, with the exception of the distinguishing features of the valves : the spring of the rebound valve is stronger than that of the bump, and the larger gauge of the wire can easily be seen on comparing the two valves.

REPAIR AND OVERHAUL OF FORD CARS

REAR AXLES, FRONT AXLES, BRAKES, STEERING AND CHASSIS

By J. W. SANDERMAN, A.M.I.A.E.

REAR AXLES

Adjustment of Drive-pinion Bearings

ONE of the most important points in overhaul of rear axles is the adjustment of the drive-pinion bearings. All these bearings are assembled with an adjustment giving a pre-loading.

A service tool is available with which this pre-loading may be measured, and it is advisable to use some such instrument to maintain the adjustment on the different models, as follows :

On 24-h.p. and 14·9-h.p. passenger cars and early V-8 cars, where the drive pinion has no pilot bearing, the pre-load should be between 15 lb./in. and 20 lb./in.

On all other V-8 cars, where the drive pinion is provided with a pilot bearing, the pre-load should be between 12 lb./in. and 17 lb./in.

The drive-pinion bearing pre-load on the trucks should be between 12 lb./in. and 16 lb./in., while the pre-loading on 8-h.p. and 10-h.p. vehicles should be between 4 lb./in. and 6 lb./in.

Drive-pinion bearings should always be a good tight fit in their housings, and when assembling a new bearing it should be shrunk into place by heating the axle casing, preferably in hot oil, until the bearing can be lightly pressed into its housing.

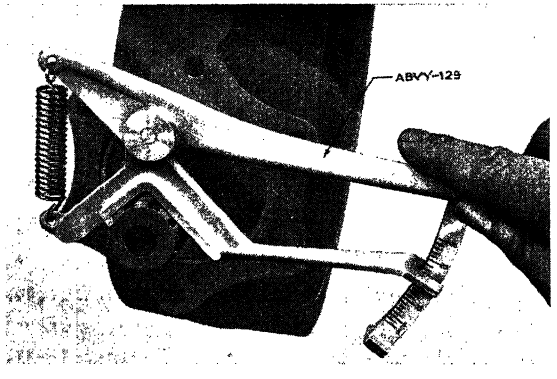


Fig. 1.—GAUGE FOR SETTING PRE-LOAD OF DRIVE PINION BEARINGS

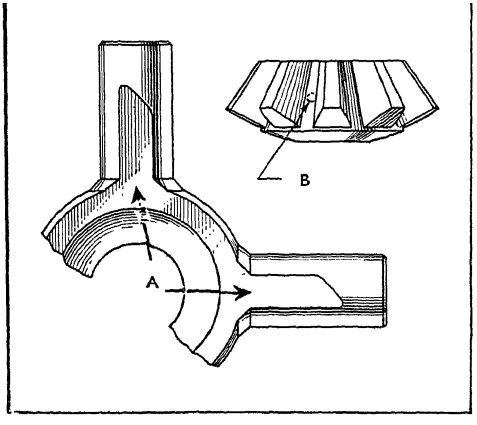


Fig. 2.—TRUCK DIFFERENTIAL SPIDER AND PINIONS

A. Lubrication flats on spider arms.

B. Oil hole drilled here when spider has no lubrication flats.

Replacing Differential Spider and Pinions

A particular point to note is the differential spider and pinions. Should it be necessary to replace these parts, the spider fitted may or may not have flats machined on each arm. These flats are for lubrication purposes and it will be found that the pinions fitted are not provided with oil holes. Should the spider have no flats on the arms the pinions fitted will have oil holes drilled between the teeth to permit lubrication, and in no circumstances should undrilled pinions be used together with spiders which do not have the lubrication flats on the arms.

End Float in Axle Half-shafts

On 8-h.p. and 10-h.p. models the thrust on the axle half-shafts is taken on a pad mounted on the differential spider shaft and a thrust face on the end of each axle half-shaft.

Should these faces become scored through faulty lubrication or should too much wear develop, this will permit excessive end float in the shafts, when the only remedy is replacement of the affected parts.

Crown Wheel and Pinion

To ensure maximum efficiency and quietness of operation, crown wheels and pinions are supplied in matched pairs and should always be replaced in this manner. It is false economy to try to replace one of these parts, however good the other may appear, as apart from any wear which has taken place, the tooth surfaces have bedded in running to the other original part and cannot be expected satisfactorily to mate with an odd new part, with the result that when the new part has bedded down excessive backlash may result, together with bad tooth contact, which can only result in rapid wear.

Reassembling 6-wheeler Intermediate Torque Tubes

In reassembling the intermediate torque tube between the two driving axles of six-wheeled vehicles, care must be taken to see that the universal joint caps and torque tube are correctly positioned to avoid damage in operation.

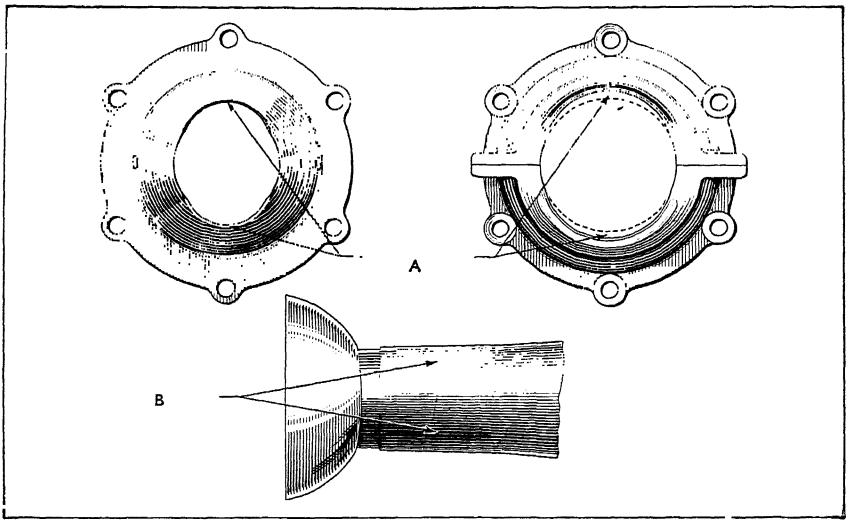


Fig. 3.—CORRECT ASSEMBLY OF SIX-WHEELER INTERMEDIATE TORQUE TUBE

A. Clearance for articulation in universal joint cover.
B. Showing points which engage in cover clearances.

It will be noted that the caps have the hole through which projects the torque tube elongated to permit maximum articulation, and these must be assembled with the elongations at the top and bottom. The early torque tubes had two clearance flats at the point where it entered the cap, which must also be assembled top and bottom. Later torque tubes are elliptical at this point and must be assembled with the lesser axis vertical.

Use of Extreme Pressure Lubricants

In view of the heavy load imposed on rear axles to-day, due to increased engine power and, in the case of commercial vehicles, increased pay loads, lubrication has become a much greater problem, and it is advisable to use only an extreme pressure lubricant in these components. The very slight extra cost is more than offset by the greater margin of lubrication safety these oils provide, as the breakdown of the oil film under pressure is approximately twice as high as an ordinary gear oil.

There are several types of extreme pressure lubricants on the market, some of which are rather unstable in service and tend to precipitate, while it is not possible to mix these with other gear oils or extreme pressure lubricants without the danger of undesirable chemical action.

It is also necessary to drain and flush out these oils at intervals so that their use is attended with some additional bother in regular maintenance.

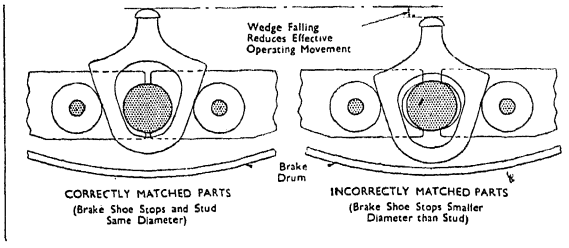


Fig. 4.—CORRECT AND INCORRECT FITTING OF BRAKE SHOES AND OPERATING WEDGES

If, however, the extreme pressure lubricants approved by Ford Motor Company are used, the above mentioned characteristics will be avoided, as these may be used in exactly the same manner as the previous ordinary gear oils.

These extreme pressure lubricants may be mixed with each other or any ordinary gear oil, although it is obvious that to obtain the best from any lubricant it is advisable to decide on one type and not to change.

These approved extreme pressure lubricants may also be used with safety in gearboxes, whether plain or synchromesh. This is a useful characteristic, as it saves the necessity of stocking an unnecessary number of oil types to ensure correct lubrication.

FRONT AXLES

Renewing Stub-axle Bushes

Few special precautions are necessary in overhauling front axles, but one of the most important is the renewing of stub-axle bushes.

These bushes being of the split type should not be reamed after replacement, but should be burnished broached, so that they are expanded securely into position and the necessary hard working-surface is formed.

Radius Rods

Particular attention should also be given to the front-axle radius rods, where these are fitted, to ensure these have not been strained, as any slight bend will throw the whole front axle out of true alignment. Should either of the radius rods be badly bent, straightening is not advisable, as in this case the metal will have undoubtedly stretched and even when correctly straightened may be slightly longer than originally, with consequent misalignment.

The rear end of these radius rods is carried in a rubber-bushed socket, and should any doubt exist as to the resiliency of the rubber ball joint this should be renewed. An unsatisfactory ball rubber will give rise to many baffling troubles, such as unsatisfactory steering, brake judder, etc.

Front-wheel Alignment Settings

Important points in front-wheel alignment are castor, camber, and toe-in ; these settings varying with different models.

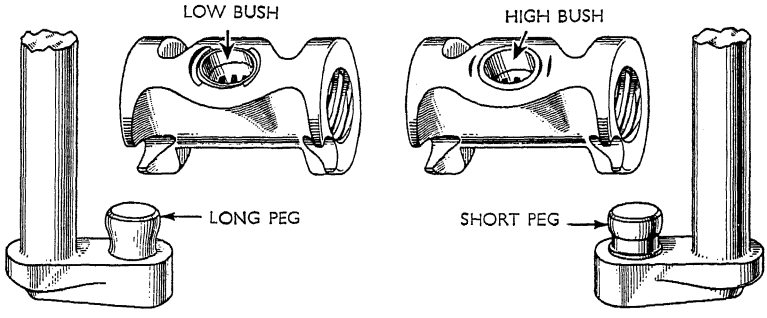


Fig. 5.—STEERING ARM AND NUT COMBINATION

The larger passenger models have a castor of 9°, a camber of 2° on earlier models or 1° on later models, and a toe-in of $\frac{3}{32}$ in.

The 8-h.p. and 10-h.p. vehicles have a castor of 8°, a camber of 2°, and a toe-in between $\frac{1}{16}$ in. and $\frac{1}{8}$ in.

Trucks have a castor of 5°, a camber of 2° in the case of early models and $\frac{3}{4}$° on later models, with a toe-in of $\frac{3}{32}$ in. on early models and no toe-in on later vehicles. The exception to these figures is the 25-cwt. forward vehicles control, where the castor is 7°, the camber 1° 7′, with a toe-in of $\frac{1}{16}$ in.

Maximum variation between the wheels should not exceed $\frac{1}{2}$° on castor and $\frac{1}{4}$° on camber.

BRAKES AND STEERING

Brake Shoe Replacement

There are very few special precautions necessary in the overhaul of these components, but when installing new or reconditioned brake shoes on 8-h.p. and 10-h.p. models see that these are of the correct type and seat correctly on the operating wedge-locating stud.

Two diameters of stud have been used, and if shoes with a different locating radius are installed, either they will drop from a concentric position or they will not be able to fully close, so allowing the wedge to drop and either score the drum when the brakes are operated or prevent full operation by coming too soon to the limit of its travel. (This applies only to wedge-operated brakes fitted prior to the current Girling system.)

In all cases where brakes are wedge operated it should be ascertained after overhaul that accumulated wear in various working parts does not permit the wedge to " bottom " on the stud before maximum pressure is applied to the drum.

Where brakes require relining it is not to-day economical to replace the linings, but far more satisfactory to take advantage of Ford Motor

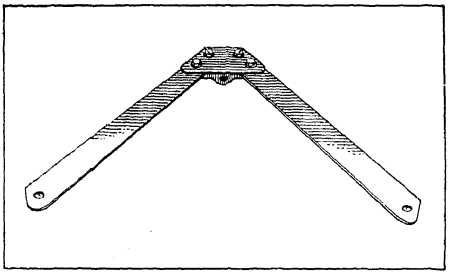


Fig. 6.—SIX-WHEELER BRACE SPRINGS. The long arm goes towards the rear.

Company's exchange scheme, where not only are shoes relined, but all other parts, such as rollers, pins, etc., replaced as required.

Assembling Steering Nut

A precaution to observe in the 8-h.p. and 10-h.p. steering gear is the assembly of the steering nut. Two types of steering shaft have been used, one having the peg which engages with the nut longer than the other, the bush in the nut used with the long peg being sunk deeper in the nut than previously.

Although it will be quite satisfactory to use the nut having the "high" bush with the shaft having the long peg, under no circumstances must the shaft with the short peg be used with a nut having a "low" bush.

CHASSIS

Replacing Complete Chassis Frame

Should it at any time become necessary to replace a complete chassis frame of 8-h.p. or 10-h.p. models, it will be found that these are rigidly attached to the body by rivets and spot welding.

Rivets should wherever possible be cut out from inside the chassis member and points of spot welding carefully broken so as not to unduly damage the body attachment flange.

It is not advised that re-riveting be attempted upon replacement, as however good the original holes may appear some distortion is sure to be present. It will be found preferable to use bright steel machined B.S.F. bolts with plain and spring washers for this purpose.

If body is damaged, the base should first be straightened up so that the securing holes line up with the chassis frame holes without undue strain. Temporarily locate the body in position with bolts, one at each end of each chassis side member and at the front of each rear wheel arch.

The remaining holes should now be drilled "dead size" $\frac{5}{16}$ in. and $\frac{1}{4}$ in. as may be indicated, so that the bolts are a light drive fit, each bolt being fitted with the head on the outside and a bright steel plain washer between the head and body flange; a nut with spring washer being inside the chassis frame.

Drill and install one bolt at a time to prevent minor body misalignment and, in the case of four-door models, position, drill, and bolt the centre pillar last of all.

Reassembling Springs

Particular care must be taken when reassembling springs to chassis cross-members that the square head of the tie bolt is properly seated in the square hole cut in the cross-member to receive it.

Failure to observe this and also to maintain U-bolts fully tightened will give rise to continual hammering, which may eventually fracture the cross-member.

A point to watch in assembling the rear-axle brace springs on six-wheeled vehicles is that the longer of each pair of spring arms is assembled towards the rearmost axle.

When these brace springs are correctly assembled and the vehicle is unloaded they should have a slight curve or camber and will have to be forced into position. This is quite in order, as under load they will straighten out to take a load in tension. Under no circumstances should these springs be flat when the vehicle is unloaded, otherwise when under load undue stress will be thrown on various components.

Assembling Steering Gear to Frame

In assembling the steering gear to the frame take care to avoid placing undue stress on this component by first positioning the steering on the chassis member with the bolts just finger tight, then secure the column support bracket to the dash sufficiently tight to correctly position the column.

All points round the steering-box bracket flange should be checked with a feeler gauge between the bracket and side-member face, and where gaps occur the bolt must be removed and the space taken up by means of suitable shims, after which final tightening can be carried out.

SERVICING PACKARD SIX, EIGHT, AND SUPER EIGHT, 1937-9

REAR AXLE BRAKES, SUSPENSION, STEERING, ETC.

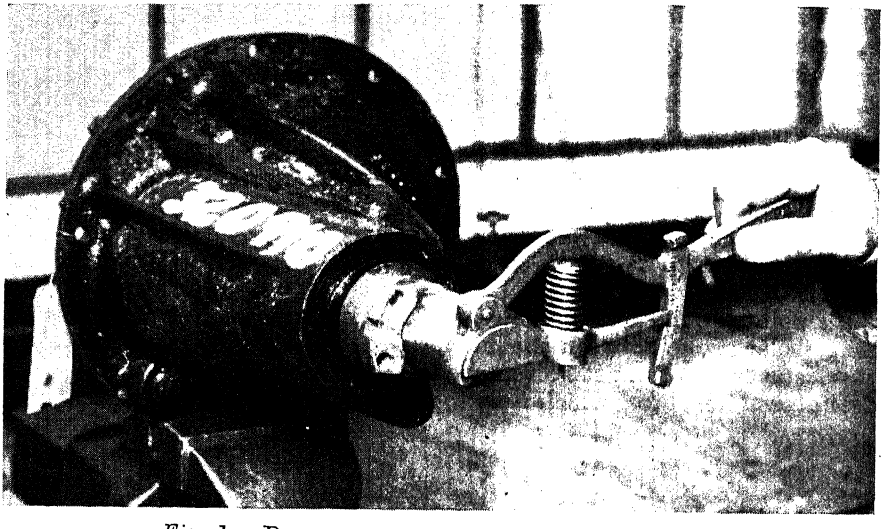


Fig. 1.—PRELOADING TEST ON DIFFERENTIAL PINION
A preload of 25-30 in./ lb. should be obtained.

Rear Axle

THE rear axle is semi-floating and has hypoid gears. The hubs are keyed on tapered half-shafts which butt at inner ends on hardened block. The Six and Eight had non-adjustable ball outer bearings in 1937, and tapered roller in 1938. Adjust by shims behind brake back plate (which retains bearing) to give 0·004–0·007 in. of end play. If end play is more than 0·050 in., adjust both sides equally.

The Super Eight has double taper roller wheel bearings. To adjust, withdraw axle shafts with outer bearing cup and inner bearing cone and rollers, remove inner bearing cup, and insert shims behind. End play is 0·002–0·004 in. on each shaft.

On models Six and Eight the pinion shaft runs on tapered rollers with

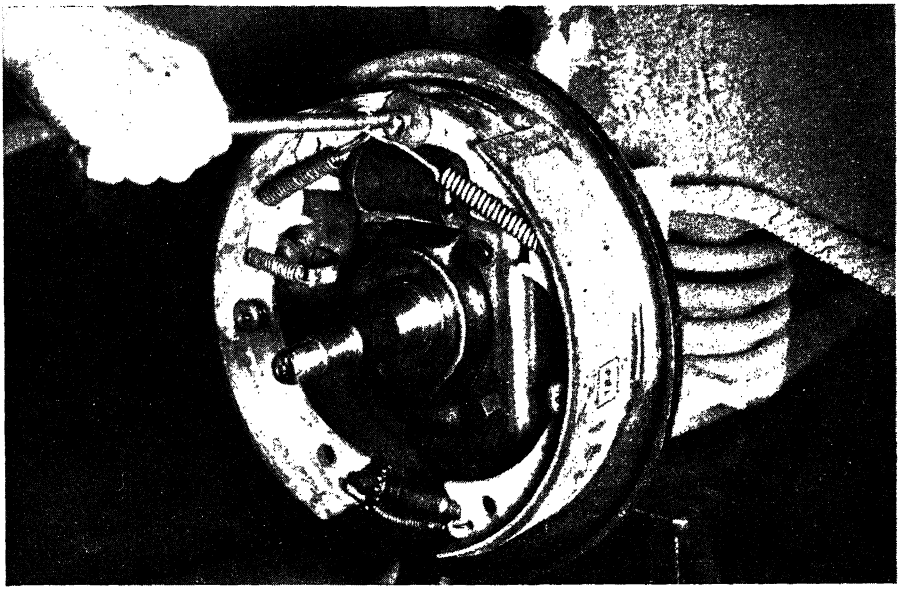


Fig. 2.—FIXING THE BRAKE SHOE SPRING
Showing also the correct way round of the primary shoe.

distance piece between. Adjust bearings by tightening self-locking flange nut until the distance piece begins to buckle, which should give preload of 25–30 in./lb. (A 5–6-lb. pull on a 5-in. spanner will rotate the shaft.) There is no mesh adjustment on the pinion shaft.

The differential bearings must be preloaded to spread bearing housings 0·010–0·012 in. Use large outside callipers and a 0·010-in. feeler against the machined bosses on bearing housings. Lock callipers, loosen caps slightly, and back off the offside bearing adjusting nut until differential assembly is loose in bearing. Back off the nearside nut, if necessary, to provide some backlash between crown wheel and pinion. Now tighten offside nut until callipers (without feeler) will just slide over bosses.

If backlash is more than 0·005 in., back off the offside nut and tighten nearside nut an equal amount until backlash is 0·003–0·005 in. If nuts are turned exactly equal amounts, preload adjustment will not be upset.

The Super Eight pinion shaft is straddle-mounted in two double-row, non-adjustable ball races. The shims behind the flange of outer bearing housing adjust pinion position.

The oil reservoir, formed by the rib of outrigger bearing housing, must be refilled every time the joint flange or pinion shaft is removed.

Differential adjustment procedure is the same as for the Six or Eight, except that preload should be 0·015-in. spread.

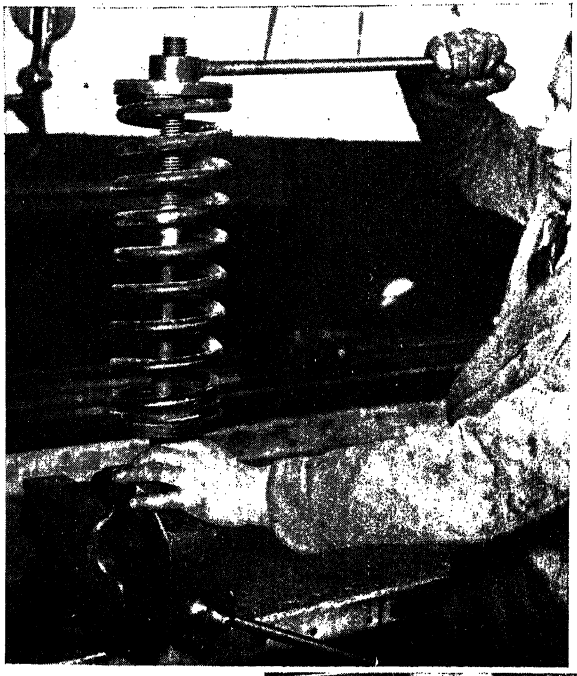


Fig. 3 (*left*).—METHOD OF COMPRESSING FRONT SUSPENSION SPRING

Brakes

Brakes are Lockheed hydraulic with Bendix shoes. The hand-brake works rear shoes by cable.

To adjust the foot-brake, jack up and remove all wheels. Remove the spring covers from adjuster slots at bottom of back plates and covers from brake-drum slots. Adjust rear shoe on each brake with 0·010-in. feeler through slot in drum at lower end by means of the eccentric at centre of shoe, and at upper end by eccentric anchor bolt at top.

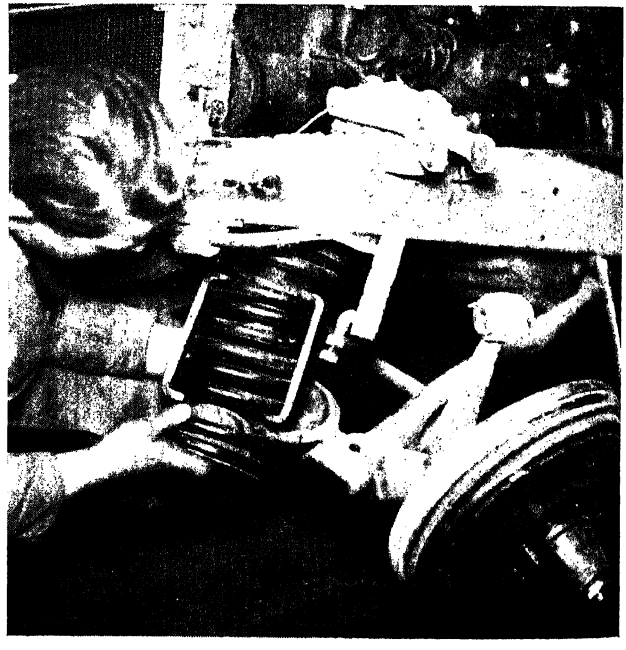


Fig. 4 (*right*).—INSERTING SPRING

Note clamps to keep spring compressed.

Turn star wheel by screwdriver through slot at bottom until slight drag is felt, then back off until just free.

To adjust hand-brake, turn the star adjuster on back wheels until wheels can just be turned.

The next step is to set handbrake lever in first notch and disconnect both cables to rear wheels. Put equaliser bar at right angles to frame side members and adjust cables until clevis pins enter freely without moving bar. Assemble pins, release lever, and back off star adjusters until the wheels are free.

The pedal must have $\frac{1}{4}$–$\frac{1}{2}$ in. of free movement before engaging piston in master cylinder.

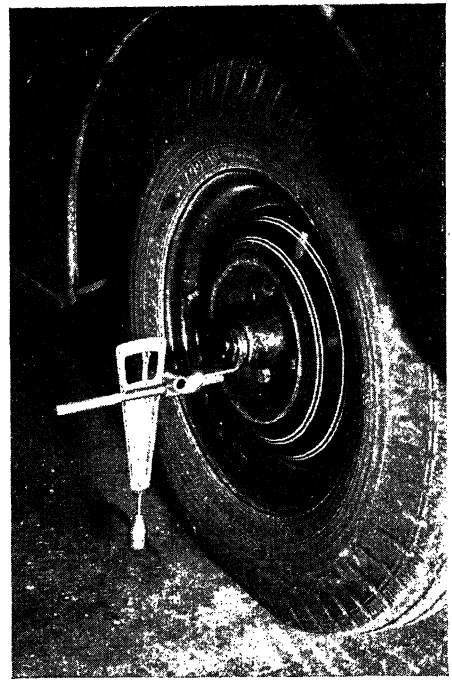


Fig. 5.—CHECKING THE FRONT WHEEL FOR VERTICAL

Front Suspension

Front suspension is independent, with coil springs. The long lower links have rubber bushes at inner ends and needle rollers at outer ends and are located by torque arms with rear ball ends in rubber bearings. The top wishbone links act direct on shock absorbers and have rubber bushes at outer ends with thimbles for camber adjustment. Thimbles are available with 0, $\frac{1}{16}$ in., $\frac{1}{8}$ in., and $\frac{3}{16}$ in. in offset. Offset of $\frac{1}{16}$ in. changes angle $\frac{1}{3}°$. Measure the camber angle with a load equivalent to four passengers.

The castor is adjustable by tapered shims between lower link and torque arm. Measure with the car loaded. Check for binding in wishbone and lower link inner bearings after adjustment.

Divided track rods have left- and right-hand threads. Turn both equally to adjust toe-in, making sure that the steering worm is in central position.

King pins are secured in the carrier arms by drive-in cotters. Welch plugs are fitted top and bottom. Knock out either way after drilling out plug. The king-pin bearings are Oilite bushes with ball thrust below wheel carrier.

Tapered roller wheel bearings are adjustable by tightening and backing off half a turn.

Rear Suspension

Rear suspension is by means of semi-elliptic springs 54 in. long and 2 in. wide, with rubber bushes at both ends. Do not lubricate the

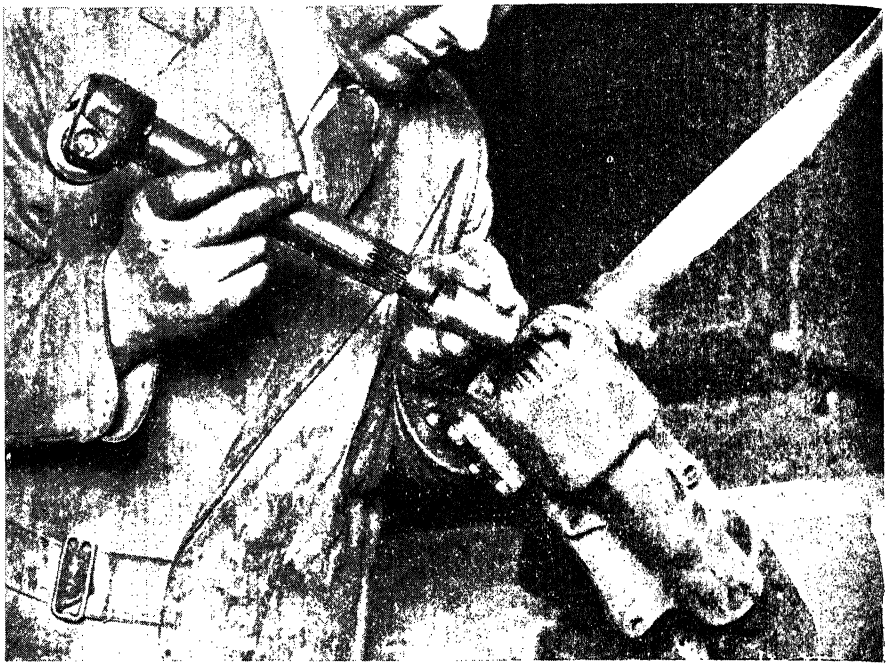


Fig. 6.—FITTING SAFETY COVER ON SHAFT TO PROTECT FELT LINING IN STEERING WHEN INSERTING SHAFT

springs. The covers act purely as dirt excluders. If shackles are dismantled do not tighten fully until weight of car is resting on the springs.

Steering Gear

Before making adjustments to the worm and double-tooth roller, disconnect the drag link from drop arm. If steering binds, loosen the frame bolts so as to align column to dash-bracket. Tighten frame bolts and release the dash bracket. Elongate holes or shim bracket, if necessary.

On the Six and Eight, three adjustments in the steering box should be carried out in this order :

Column up-and-down play.—Turn wheel to either stop and back $\frac{1}{8}$ turn. Loosen column bottom-end cover screws about $\frac{1}{8}$ in. and remove shims until slight drag is felt at wheel when cover is bolted up.

Cross-shaft end play.—With wheel near one lock, turn adjusting screw to take up all play.

Roller mesh.—Turn wheel to mid position and test drop arm for backlash. Remove drop arm and side cover plate and take out cross-shaft with roller. To prevent damage to oil seal at drop-arm end of shaft, tape the splines and withdraw shaft carefully. Remove shims behind

roller until no backlash is felt at mid position while shaft is held in by thumb-pressure.

Before refitting cover, back off end-play adjusting screw and readjust after tightening bolts.

Test wheel for slightly greater drag at mid position than on locks.

On the Super Eight, the column up-and-down play is adjusted as on the Six and Eight.

Roller mesh and cross-shaft end play are both controlled by adjusting screw on end of shaft. Remove cap nut and locking washer and turn screw with square-ended bar until slight drag is felt with wheel in mid position. Refit locking washer without altering adjustment and replace the cap nut.



Fig. 7.—INSERTING DE-CENTRED BUSHES ON STEERING

Shock Absorbers

Packards are fitted with hydraulic double-acting, non-adjustable shock absorbers, Delco on Six and Super Eight, and Houdaille on Eight, 1938 and Delco on all 1939 models. Front shock absorbers are incorporated in the upper wishbone link. Rear shock absorbers on Six and Eight are mounted on the axle, offside arm to front, incorporating anti-roll bar, and nearside arm to rear.

Shock absorbers are mounted on the frame at the rear on Super Eight with an anti-roll bar between.

REPAIR AND MAINTENANCE OF TILLING-STEVENS CHASSIS

PROPELLER SHAFT, AXLES, STEERING, AND BRAKES OF PASSENGER (TYPE HA39A7) AND GOODS (TYPE HA39C4) MODELS

By F. J. HUGHES, M.S.A.E., A.M. INST. T.

PROPELLER SHAFT

Needle-bearing Type

OILS recommended: Mobilgrease No. 2, Castrol "D," Shell Spirax.

This shaft consists of two portions, the forward or intermediate half, from rear of gearbox through a self-aligning ball race in the main frame cross-member, coupled to the rear portion or propeller shaft proper.

The three joints are of the needle-bearing type, and apart from lubrication with gear oil every 3,000 to 4,000 miles, or fortnightly, require practically no attention. Lubricant is applied through a gun nipple on each trunnion cross, one for each joint, while the forward splined slip-joint end of propeller shaft proper has a gun nipple, also for gear-oil lubrication on the rear yoke.

Lubrication for the self-aligning bearing mounted in the cross-member is supplied from a nipple in the battery mounted on the cross-member just forward of the rear axle.

Dismantling

If it is desired to examine the needle bearings, the two lock-screws are first removed, then the lock straps and cover plates. The needle-bearing assemblies will then slide freely out of the yokes. Reassembling merely reverses the above process, the whole operation being possible without removing the joint from the chassis.

The rear portion or propeller shaft proper can be entirely dismantled from chassis by removing the eight flange-coupling bolts at each end. It is advisable to mark each pair of flanges so that they are replaced in the same place. When reassembling, it is important that all bolts and nuts are split-pinned.

Access to, or renewal of, self-aligning bearing in cross-member is

obtained by drawing off flanged end of shaft and removing dust cover on housing secured by six nuts.

When assembling slip joint on the shaft, care must be taken to assemble so that the sleeve yoke lugs lie in the same plane as stub ball yoke lugs. Arrows are stamped on sleeve and shaft for this purpose.

REAR AXLE

Oils recommended : Mobiloil " C," Castrol " D," Shell Spirax.

The rear axle is of the fully floating type with underslung worm and four-pin differential. Two axle ratios are available, 5·75 and 6·4, and each worm case is stamped on the offside rear with the ratio fitted.

An oil-level indicator and filler combined is fitted to the rear of each worm case, and the correct level is just below top of filler, which is exposed by opening the hinged lid. Gear oil is recommended for lubrication, and a weekly examination of oil level is desirable. This is best carried out when the axle is warm, as the oil flows more freely.

The front end of worm shaft is fitted with an adjustable packing gland to prevent oil leakage.

To tighten gland, release the two rear nuts and tighten the two forward nuts an equal amount, after which, the two rear nuts should be brought up and locked. Gland should not be over-tightened, and usually about two complete turns of adjusting nuts will be found sufficient.

Worm-shaft Oil Gland (Type HA39C4 only)

The gland housing is packed with three packing rings of special material, which alone should be used for replacement purposes.

To stop oil leakage, turn the gland nut in a right-hand direction until the worm-shaft can just be moved by hand ; compression of the packing to a greater extent than this will result in rapid wear of the shaft as well as of the packing.

The gland nut is retained in position by a steel locking-plate, which is held by one of the studs securing the gland housing to the casing. The locking-plate must always be refitted so as to engage with one of the slots of the gland nut.

To remove worm and wheel for inspection or adjustment, disconnect flanged joint at rear of propeller shaft by removing eight bolts. While this operation is in progress the oil can be draining from the worm casing through a plug hole for this purpose. Then disconnect Lockheed anchorage at each side of axle, one bolt and one set screw at the top end of each anchor plate, to allow Lockheed cylinders to swing clear of axle tie-rod nuts.

Axle tie-rod nuts should then be removed and rod lifted clear. From chassis 8778 onwards, it is not necessary to disconnect Lockheed anchorage to remove axle tie-rod. To remove tie-rod on these chassis, release tension by slackening turnbuckle, then, after removing split pins from each bar at end of rod, bars can be withdrawn and the rod lifted clear.

The nuts securing the rear-wheel driving dogs should next be removed and the driving-dog joints broken by means of forcing screws introduced in the two tapped holes provided. The two differential cross-shafts, complete with driving dogs, can then be withdrawn. After providing sling around unit, or packing under worm housing, remove the bolts securing the worm casing to the axle and break the joint by means of the forcing screws in the four tapped holes, when the complete unit, consisting of worm, wheel, and differential gear, can be lowered clear. This work is best carried out over a pit, otherwise rear axle must be raised to allow worm gear to be completely withdrawn.

Reverse the sequence of operations for reassembly.

Removal of Worm-shaft and Bearings from Worm Casing

(1) Remove the universal joint coupling from the tapered end of the worm-shaft.

(2) Remove the gland and gland housing.

(3) Remove the rear end-cover.

(4) Tap out the worm-shaft in a backward direction. The inner race of the front roller bearing will remain on the shaft ; the rear ball bearing and the ball thrust bearing will also remain on the shaft and can be removed after the locknut has been taken off.

Removal or Adjustment of Rear Hubs (Timken Bearings)

Lubricants recommended : Gargoyle Grease " BB," Castrolease Light, Shell R.B. Grease.

Having removed the wheels, remove nuts securing driving dogs, and withdraw shaft as detailed under rear-axle instructions. After wiping away lubricant, the locknut is exposed, held in position by a special locking washer bent down over one of the flats of the nut. Straighten out this washer by means of a screwdriver, or other suitable tool, after which the nut can be unscrewed in a left-hand direction on nearside and right-hand on offside. Then pick off locking washer and tongued washer next to it, afterwards unscrewing the special disc with tool provided in equipment. The hub is then ready for removal and examination of bearings, etc.

Reverse the sequence of operations for reassembly.

Adjustment is best accomplished by drawing up the adjusting or inner nut reasonably tight, and at the same time rotating the hub several times. The object of this is to ensure that all component parts of the bearing are properly seated in the interior of the hub. After having drawn the adjusting nut up tightly, it should be backed off one-third or one-half turn to a point where the wheel is free running, but not sufficient to permit of more than just the least perceptible shake in the bearings. The adjusting nut should be locked in the final position.

The two threaded nuts, with key washer between, form a combination

in which the inner nut is positively locked against rotation, while the outer nut clamps the parts solidly together. By offsetting the tongue, or flat, in the key washer one-quarter of the hole spacing, an increment of adjustment of one-half the hole space is possible by reversing the key washer.

Springs and Shackles

The spring clamping bolts on both axles should be kept tight to prevent broken springs and brake troubles. All spring shackles are lubricated by grease-gun from grouped nipples placed in accessible positions, and clearly indicated in lubrication diagram.

The springs should be kept reasonably clean in order that a broken leaf may be readily apparent. In addition, a spring kept in good condition and free from rust gives better riding qualities.

It is considered a good plan to separate, periodically, the spring leaves, and introduce graphite grease by means of a knife blade, or steel strip, to further increase riding comfort, and obviate those annoying little squeaks so prevalent on many vehicles kept in continual service. The separation of the spring leaves is best affected by taking the weight off the spring to be so treated, then after slackening the clamping bolts and clips the leaves can be forced apart by a chisel or stout screwdriver.

STEERING

The steering gear is a Marles cam and roller type with an overall reduction of 20½ to 1. About three and three-quarter turns of the steering wheel are required for turning from one full lock to the other.

Steering Box

No adjustment of the cam and roller or of the bearings in the steering box will be required until a lengthy period of service has elapsed, but in the event of accidental damage, which necessitates the dismantling of the box, the following methods of adjusting the engagement of the roller in the cam, and of the cam bearings, should be followed :

Adjustment of Cam and Roller Engagement

(1) Remove the drop arm from the rocker-shaft, taking care first of all to mark both so that they may be refitted in the same relative position.

(2) Remove the rocker-shaft from the steering box.

(3) Remove the nut and lock-washer from the rocker-shaft bolt, and withdraw the bolt about ⅜ in., so that its serrations near the threaded end are just clear of the serrations in the rocker-shaft hole.

(4) Adjust the depth of engagement by turning the bolt with a spanner. The engagement should be close enough to ensure that there is no trace of backlash when the roller is in the *centre* of the cam, and only a slight

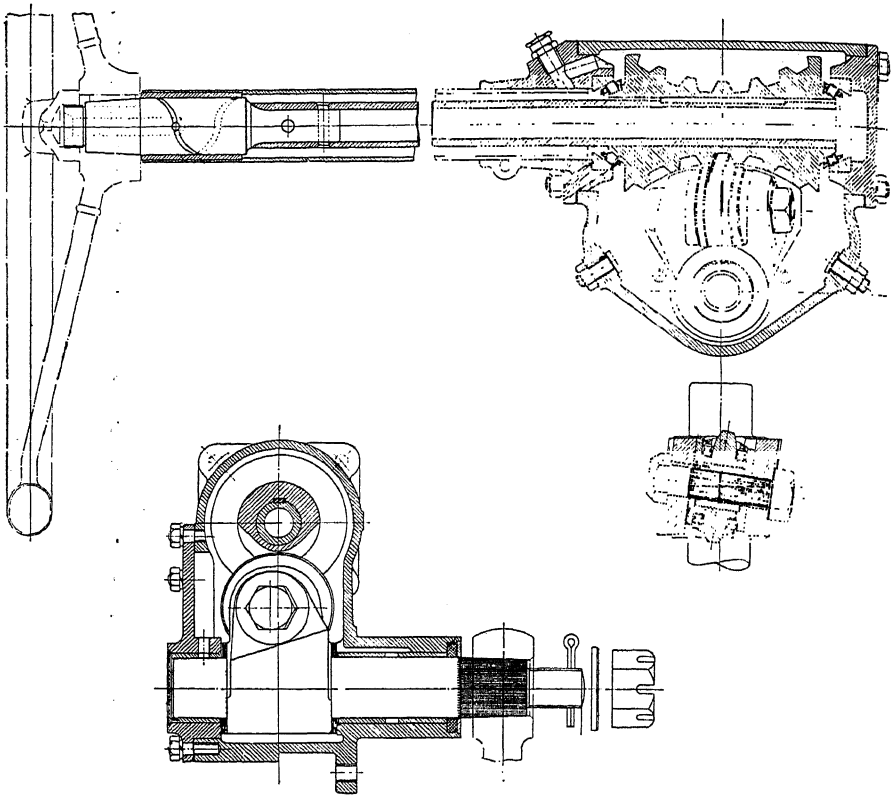


Fig. 1.—THE STEERING GEAR

amount at the extreme ends of the cam-and-roller movement. (The roller assembly is mounted on an eccentric distance piece, and turning the bolt clockwise will raise the roller into the cam.)

(5) Push the bolt home again into the rocker-shaft and replace the lock-washer and nut.

Adjustment of Cam Bearings

(1) Unbolt the column support from the steering-box casting.

(2) Remove or insert one or more shims (Part Nos. 2616 and 2617) between the column-support end face and the box casting, so that the cam has no end-play when the column support is again bolted in place. Similar shims are inserted between the box casting and the bottom cover, but these should not be disturbed, as they are for centring the cam relative to the rocker-shaft.

Steering Side-tube and Tie-rod

The steering side-tube has ball-and-socket joints which are provided with strong springs to take up wear. For convenience in the assembling of the chassis, the tube is made adjustable for length ; its correct length is set at the works and must not be altered.

The ball socket housings of the tie-rod are screwed right- and left-hand on to the ends of the rod and secured by pinch bolts. After any adjustment to the length of the rod, the pinch bolts must be well tightened and the nuts must be split-pinned.

Alignment of the front wheels should be checked periodically, and the wheels kept between parallel and a " toe-in " not exceeding $\frac{1}{8}$ in. measured at the height of the wheel centres ; any deviation from this will result in excessive tyre wear.

The lock of the front wheels is limited by adjustable stops fitted at the front ends of the axle-bed. It is *most important* that the axle stops, on either side, should come into action *before* the stops in the steering box ; damage to the roller assembly will result if the steering-box stops are used for limiting the lock of the front wheels.

Frequent and regular lubrication of all parts of the steering gear, and of the front-axle pivot pins and thrust bearings, is necessary to retain ease of steering.

FRONT AXLE

The front axle-bed, which is of channel section, is a heat-treated alloy-steel forging. Phosphor-bronze bushes are provided for the swivel pins, and the load is taken on tapered roller thrust bearings.

The front hubs run on tapered roller bearings, which have a simple means of adjustment.

If it should be necessary to straighten the axle-bed after an accident, it is important that it should be correctly heat-treated afterwards. *In cases of emergency only*, when proper facilities for heat-treatment are not available, the axle-bed may be heated in a smith's forge, for instance ; but great care must be taken not to heat it beyond incipient red, that is, a barely visible red when viewed in the shade or in a dull light. If a smith's forge is used for heating-up, it is most important that the heating be done gradually so as not to overheat the edges of the flanges.

Adjustment of Swivel-pin Thrust Bearings

(1) Jack up the axle to remove the load from the bearing.

(2) Take off the bearing cover and extract the split pin.

(3) Swing the pivot to and fro, and whilst doing so screw down the swivel-pin nut until the swivel can only just be moved.

(4) Unscrew the swivel-pin nut a sixth of a turn.

(5) Refit the split pin and replace the bearing cover.

The rear brakes are fitted with $\frac{9}{16}$-in. and the front with $\frac{1}{2}$-in. adjusting setscrews at the extremities of each cam lever, all facing forward.

The adjustment operations are similar for all four brakes, so that a description covering one single adjustment is sufficient for all.

First slacken locknut, and then turn setscrew clockwise to take up wear, and anti-clockwise to increase clearance. When correctly adjusted there should be approximately $\frac{3}{32}$-in. clearance between end of setscrew and button on Lockheed cylinder lever, or alternatively, not less than ·008 in. between brake liners and drums, which can best be ascertained by feeler gauge. Once the correct adjustment has been obtained, carefully tighten locknut on setscrew.

To adjust Hand Brake on all Chassis up to No. 8778

The hand brake operates on the small rear drums only. The adjusting nuts are situated at the ends of the rods connected to the brake-cam levers, just forward of the rear axle. It is recommended this brake is adjusted when hand-lever range exceeds three-quarters of its travel.

Slacken the forward adjusting nut and follow up with rear nut until the range of hand lever has been reduced to approximately one-third travel. The forward nut should then be securely tightened. Although a balance link is fitted, it is preferable to make sure each side has the same amount of travel, and not only to see that the shoes come into contact with the drums simultaneously, but also are clear of the drums when brake is " off."

To adjust Foot or Hand Brakes on Chassis 8778 onwards

When pedal or hand lever exceeds approximately three-quarters of its range, the brakes should be adjusted independently front and rear by the setscrews on the cam levers supplied for this purpose. The actual adjustment operations are similar to those already described under " Foot Brake."

No foot- or hand-brake adjustment is necessary other than already described. Do not on any account alter rod lengths from pedal to servo, or from servo to Lockheed master cylinder tank.

Shock absorbers are not fitted as standard.

RADIATOR

If the vehicle is to be left standing for any length of time in an unheated place during frosty weather, all water should be drained from the radiator and engine, by the removal of the plug in the bottom tank and the opening of the drain taps on the water pump and the water-inlet pipe to the cylinder block. When water ceases to run out, the engine should be started up and allowed to run for a few moments to get rid of the last traces of water.

REPAIR NOTES ON S.S. JAGUAR CARS

REAR AXLE, BRAKES, FRONT AXLE, STEERING, AND SPRINGS, ON 1½-, 2½-, AND 3½-LITRE

By D. H. WARREN

Rear Axle

TO take out the axle centre assembly, the dismantling sequence is as follows :

(1) Disconnect rear prop shaft flange.

(2) Remove wheels, brake drums, and anchor plates.

(3) Take out bolts holding axle end-pieces to main banjo and withdraw axle shaft and hub complete.

(4) The axle centre piece is then free to withdraw after undoing the nuts which hold the surround flange to the banjo.

The repairer will be well advised to make use of the special service facilities for differential units provided by the works. It will be realised that silent running of the gears is sometimes difficult to obtain once their mesh has been disturbed or even when new gears have been fitted, unless it is possible to bench test under working conditions. In addition, in some cases certain modifications have been introduced by the manufacturers to provide greater strength. S.S. Cars Ltd. are in a position to service on very economical terms any differential assembly which may require attention, and a service axle-centre assembly may be obtained on application.

After considerable service, the axle shafts may develop end float. This can be adjusted out by jacking-up *both* rear wheels, withdrawing one shaft and taking out one or more of the shims, which are fitted between the banjo end-piece and hub retainers. It is necessary to leave ·006-in. end float after adjustment.

Brakes

All S.S. Jaguars are fitted with the well-known " Girling " brake system. Ordinary adjustment is effected by means of the adjustors on each brake-carrier plate, and under normal circumstances it is not necessary to interfere with the setting of the brake rods.

The brake shoes are readily accessible for replacement after removing wheels and drums, and it is always advisable to obtain from the manufacturers or authorised dealers service brake shoes where linings on the old shoes have become worn. Replacement brake shoes are fitted with

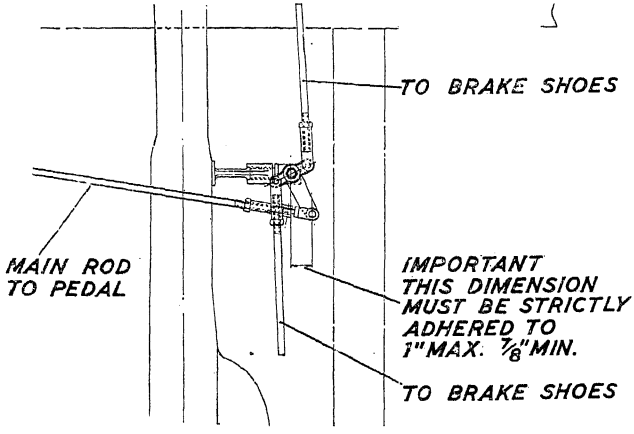


Fig. 1.—GIRLING BRAKE ROD COMPENSATOR LEVER SETTING—"OFF" POSITION

linings which have been finished and ground to shape, and on returning the original shoes a proportionate allowance is made.

Due to possible ingress of mud, etc., the expanders may tend to become seized after a period of service, but with the drums removed it is a simple matter to withdraw the cones and plungers for cleaning and lubricating. In addition, it must be remembered that the expander housing should be free to slide on the brake-carrier plate.

If, for any reason, the setting of the brake rods is disturbed, it is firstly necessary to set the transverse rods on both axles so that the compensator lever attached to each axle gives maximum leverage when brakes are applied. The "off" position of the lever is shown in Fig. 1. In connecting up the main front and rear rods, they should be adjusted in length so that the swinging linking behind the foot pedal is parallel with the chassis cross-members when brakes are applied. On 1938/39 models the right setting is obtained when the stop-pin for the main compensator is central in clearance hole with brakes "off" (see Fig. 2). Make sure that brake-rod coupling unions are tightened securely and that each clevis pin is safely split-pinned. It is usual for all clevis pins and jaws to be slack fit.

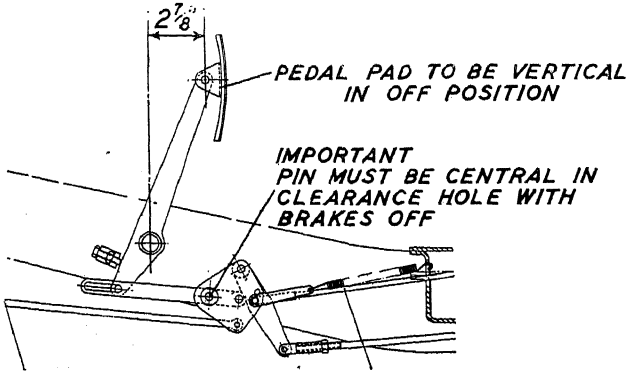


Fig. 2.—GIRLING BRAKE SETTING (1938/39 MODELS)

Front Axle

The front hubs are fitted with "Timkin" taper-roller bearings, and

where looseness in the hubs develops it can usually be taken out by tightening up the adjusting nut which will be seen inside the hub shell. After taking out the split pin the nut should be pulled up by finger pressure and then released about one castellation, it being necessary to leave a slight perceptible shake in the front hub when fully adjusted. The procedure in dismantling stub axles is as follows :

(1) Remove wheels, brake drum, and brake-carrier plate, complete with shoes.

(2) Take out swivel-pin cotter in axle beam and knock off swivel-pin top dust-cap which is riveted to the pin. The pin can then be knocked out in a downward direction and the stub axle is thus released. New bushes, if necessary, are pressed into the stub axle and will need a little scraping-in.

If the swivel thrust bearings as fitted to the 2½- and 3½-litre models are pitted, they should be replaced.

Front Springs

The front eye is phosphor-bronze bushed and is released by withdrawing the shackle pin. On all models other than 1936/37 1½-litre, the rear end of the front spring slides between phosphor-bronze trunnions enclosed in a bracket attached to the chassis frame. Unless due to neglect these trunnions do not wear, but a sharp knocking noise can occur due to lack of grease or after fairly high mileages, due to sideplay of the spring in the trunnion bracket. In such cases, side play can be adjusted by taking out one or more of the shims which are placed between the trunnion side plate and bracket proper. The lead-coated springs, as fitted from 1937 onwards, should not be lubricated.

Steering Column

The steering head controls, complete with tubes, are withdrawn from the top after releasing in the following manner :

(1) Disconnect horn and trafficator leads in junction box on steering-box cover.

(2) Take off ignition-control lever below steering box.

(3) Slacken off setscrew on clamp at steering-box base, i.e. the clamp locating the outer control tube.

(4) Take out two small grub-screws in steering-wheel boss.

The steering wheel is splined on to the inner steering tube and its top movement is restricted by a circlip which is accessible after taking out the central head. Slackness in the top column thrust race may be taken out by adjusting the thrust-race adjusting nut, above which is a locking nut. The complete steering column may be removed from the chassis after dismantling the wheel and controls as above described, disconnecting the steering-box bracket on the chassis frame, and then lifting and drawing

out the complete unit towards the front. Operations are facilitated by first removing the offside headlamp.

Shock Absorbers

" Luvax " hydraulic shock absorbers are fitted to all models. It is unwise to interfere with the valve adjustment of the vane type unless strictly necessary, as the only maintenance normally required is topping up the oil level. Special " Luvax " oil must be used for this purpose, and the oil level should be maintained to within about $\frac{3}{4}$ in. of the top of the chamber. If required for any reason, the relief-valve adjustment will be found beneath the filler plug.

The piston-type shock absorber fitted on later models have no adjustment, and a special fluid, different from that for the vane type, must be used for topping up the oil level.

Removing Starter Motor ($1\frac{1}{2}$-litre models)

As there is little clearance round the starter motor it is necessary to move aside the steering box. To do so the steering-box main attachment bolt should be taken out, when it will be found that the column can be moved sufficiently to clear the starter. On 1938 models the same procedure may be applied unless it is preferred to remove the sump.

Rear Springs

On all models the rear springs are fitted with silentbloc bushes which require no lubrication. From 1937 and onwards the springs are lead coated, and it is inadvisable to lubricate the spring leaves, as this tends to make them too flexible.

The rear springs are removable after driving out the shackle pins and disconnecting the U-bolts. The rear shackle pin can be reached by lifting out the rear boot floor.

HUMBER INDEPENDENT FRONT-WHEEL SUSPENSION

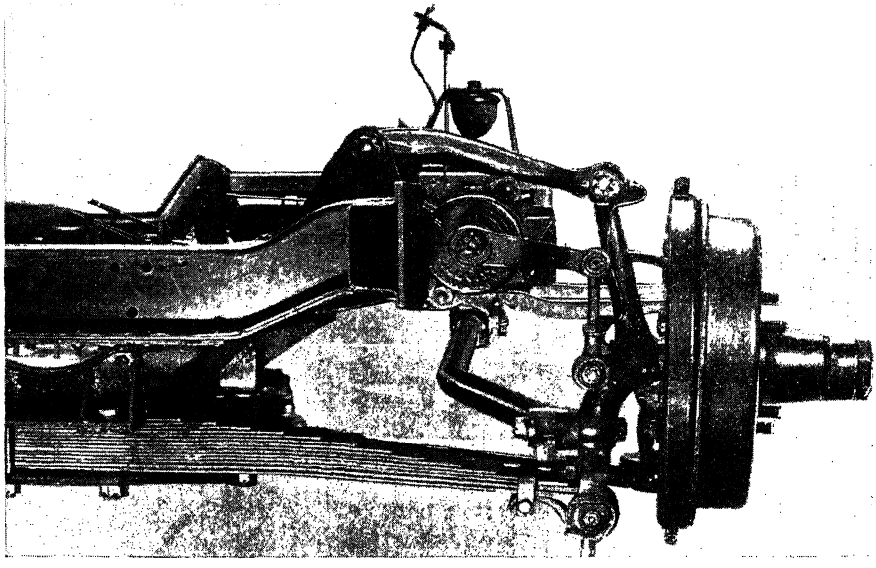


Fig. 1.—GENERAL VIEW OF SUSPENSION
(Imperial and Pullman Models.)

IN writing on the subject of Humber independent front-wheel suspension, it is felt that, to avoid confusion, it would be advisable to divide this article into two parts: (1) The suspension fitted to the Pullman and Imperial; (2) a slightly modified type fitted to the Super Snipe, Snipe, and Sixteen models.

SUSPENSION ON IMPERIAL AND PULLMAN 1939 MODELS. ALSO ON 1936–7 18-H.P., 1936–7 SNIPE, 1938 SNIPE IMPERIAL

General Description

The term "Evenkeel Suspension" is used to indicate that these improvements in the suspension, which at first sight appear to concern only the front wheels, do, in actual fact, improve the riding in the rear

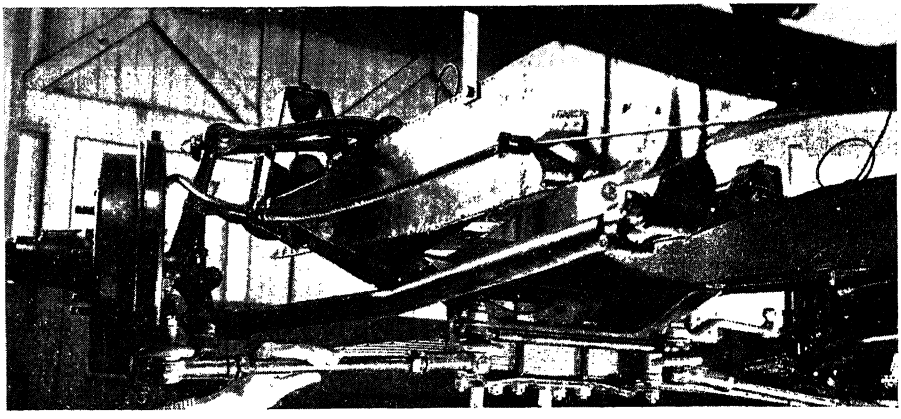


Fig. 2.—TRACK-ROD ADJUSTMENT
(Imperial and Pullman.)

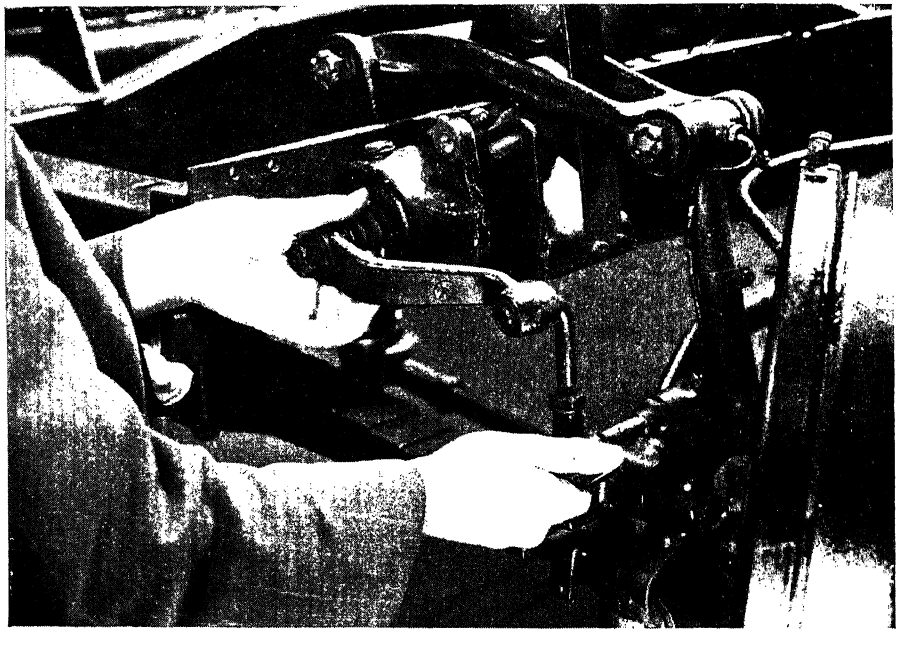


Fig. 3.—SHOCK-ABSORBER REMOVAL
(Imperial and Pullman.)

seats. With the orthodox rigid axle suspension, it is necessary to limit the vertical movement of the front wheels on account of the fact that the bulk of the steering gear moves with the front wheels, whereas with the independent-suspension system incorporated in this case, the wheel movement has no effect on the steering, and thus a vertical wheel movement, approximately equal to similar movements of the rear wheels, is obtained.

The front springs, therefore, absorb the road shocks as effectively as the rear springs, and thus there is no transmitted effect from the front which is apt to pre-compress the rear springs, leaving them in an unsuitable condition to receive their own road shocks.

From an examination of Fig. 1, it will be seen that the suspension consists of the portion carrying the stub axle, known as the stub carrier, which is hinged relative to the chassis frame on an upper link or wishbone, the leaf spring itself forming the lower link. It will be noted that the lower link thus formed is considerably longer than the upper link and it is, therefore, a matter of simple geometry to arrange the layout so that the wheel track does not vary with the movements of the spring, such lengthening of the spring being absorbed by very slight alterations to the wheel camber. In other words, instead of the whole wheel swinging outwards, as it would at first appear, the track in contact with the ground remains constant, whilst the other extremity of the wheel moves outwards when the spring is flexed.

As will be well known, the eye of a leaf spring does not move in a true radius about the clamp of the spring, but at a point approximately a third of the distance to the eye, so that if the track rod is hinged at the same point, it will move parallel with the lower leaf of the spring, and thus vertical wheel movements will not introduce a steering reaction, one of the most important advantages gained by this form of suspension.

The Track Rod

The track rod is, therefore, divided into three portions, the centre portion being a rigid link connecting the two centre steering levers; the ball joint connecting the steering to the box is incorporated on one of these centre steering levers, which is built rigidly on the chassis frame, and thus this section of the steering gear does not move at all when the wheels encounter road undulations.

The bearings in the spring eyes and also the bearings at each end of the top link are parallel one with another, so that the wheel movement is truly vertical when regarded from the side. All steering angles are arranged in the stub carriers themselves, so that in the event of this suspension being damaged in an accident, causing any of the steering angles on one side to disagree with those on the other side—and yet it be found that the six bearings are parallel one with another—it is a definite

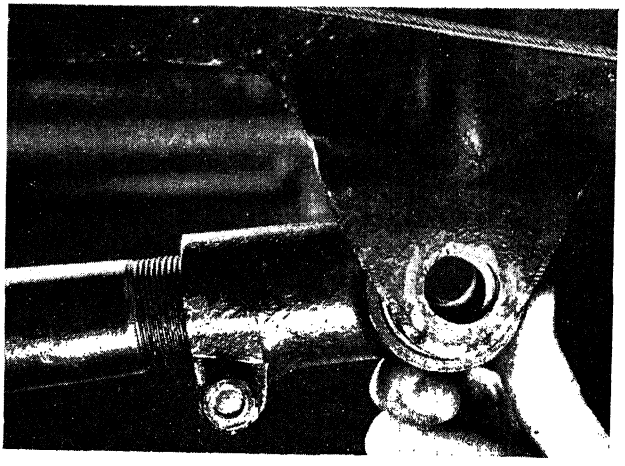


Fig. 4.—TORQUE ROD INCORRECTLY ADJUSTED
(Imperial and Pullman.)

indication that the stub carriers themselves are bent. Details of the steering angles are given later.

MAINTENANCE SERVICE

Lubrication

From two nipples fitted on each front wing below the bonnet, engine oil is fed to the bearings of the top link, and from that point passes along an external pipe down the stub carrier to the swivel pins, an arrangement being made internally in the swivel pin so that the top bush receives the lubricant before it flows by gravity to the lower bush and thrust bearing.

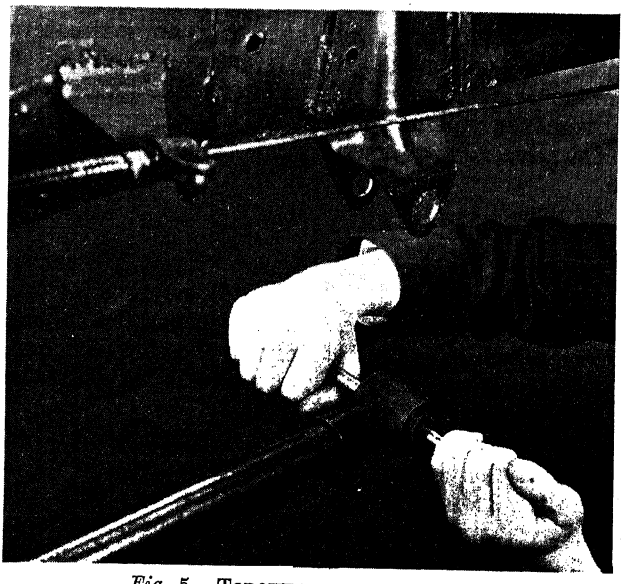


Fig. 5.—TORQUE-ROD ADJUSTMENT
(Imperial and Pullman.)

These oil nipples should be lubricated every 500 miles, and at the same time the front shackle pins should also be lubricated with engine oil.

The only other points on this suspension requiring lubrication attention are the ball joints of the steering linkage. These should be greased every 1,000 miles. The other bearings are either packed with lubricant during assembly or do not require lubrication.

On later models the front spring is covered by leather gaiters, and it should be noted that only certain lubricants are advisable. Softer lubricants are inclined to run out and stiffer lubricants will not penetrate between the leaves. The lubricant recommended is Shell Retinax.

Track Rod

Periodically, particularly when the vehicle is new and the spring is settling, the toe-in of the front wheels should be checked, this being tested in an ordinary manner on the treads of the tyres at the height of the hubs. Should it be found necessary to adjust the track rod, this is carried out on the two side track rods, and great care must be taken to maintain these two track rods at equal lengths. When the adjustment is completed, it must be checked by measuring across the greasers incorporated in the ball joints.

Shock Absorbers

The shock absorbers are of the constant-pressure type which give the maximum resistance to low-pressure movements, such as roll, but owing to their special design, work as normal shock absorbers when submitted to high-pressure movements, such as those caused by the ordinary wheel movement over undulating roads. These shock absorbers should not be adjusted, but should be periodically topped up with the recommended Luvax fluid.

Torque Rods

It will be seen that massive torque rods are fitted between the chassis frame and the stub carriers. Actually, these torque rods are not connected with the actual suspension, but are fitted to absorb the brake reaction. As these torque rods are of considerable length, it will be appreciated that the ends describe a very wide arc, which is, to all intents and purposes, a straight line, similar to that described by the stub axle. The slight difference is absorbed by the rubber bushes on which the torque rods are carried.

Should it be necessary to adjust the torque rods, the end pivoted on the chassis frame should be released and the car raised by a jack placed directly under the centre of the spring. When the front wheels leave the ground, the bush in the rear bearing should be compared with the holes in the chassis frame bracket, and adjustments carried out so that these coincide ; the pin can then be easily inserted.

As it is at all times undesirable to place unnecessary strains on these silent-bloc bushes, the car should be lowered and allowed to assume its normal loaded position before the silent-bloc bushes are clamped.

Steering Ball Joints

The four ball joints incorporated in the track rod are of the self-adjusting type, but the two ball joints on the drag link are adjustable, the

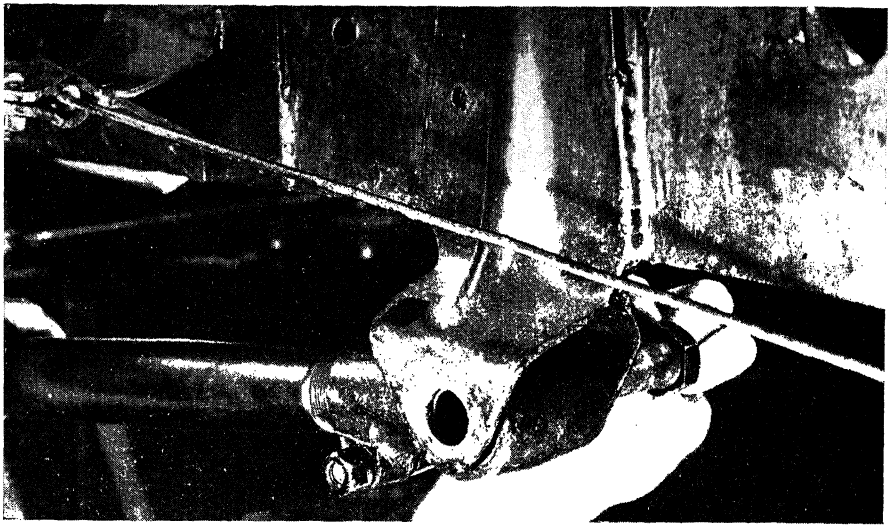


Fig. 6.—TORQUE ROD CORRECTLY ADJUSTED
(Imperial and Pullman.)

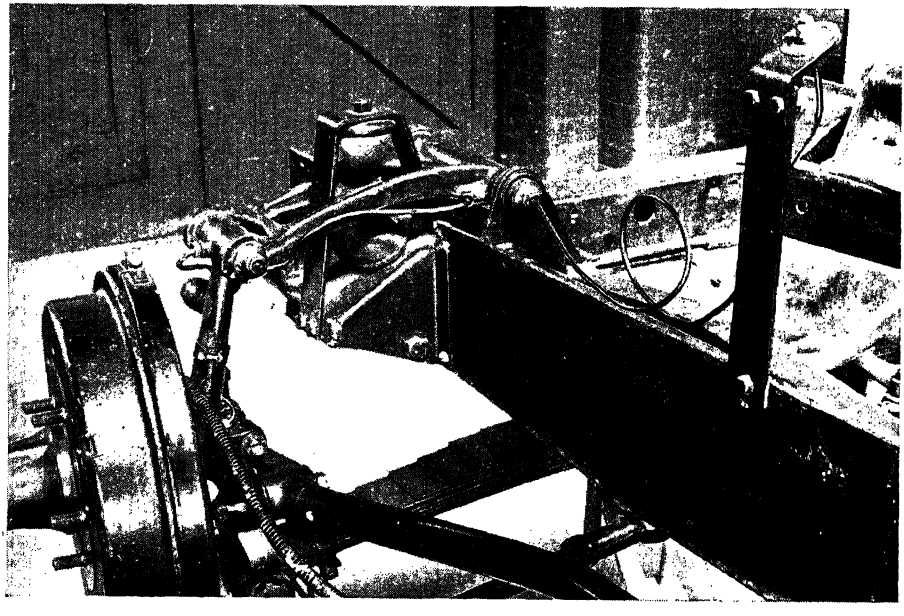


Fig. 7.—OIL-PIPE LAYOUT
(Imperial and Pullman.)

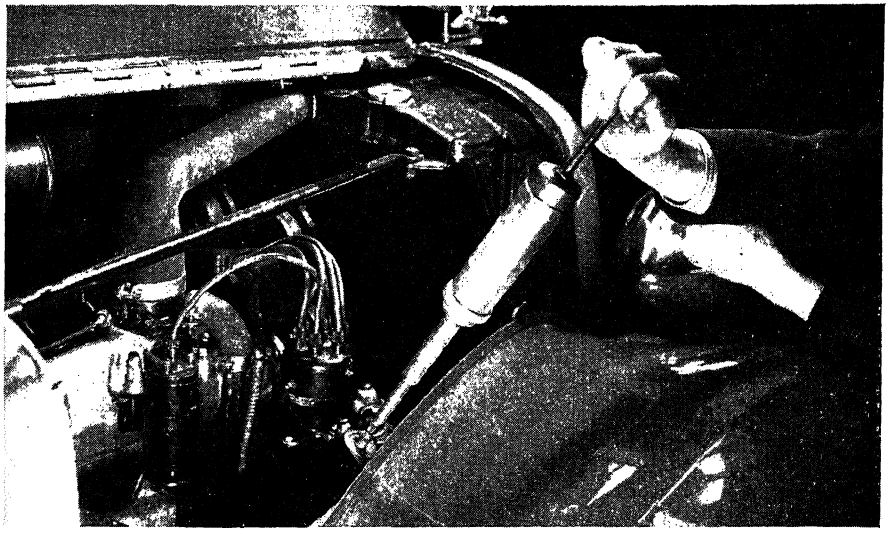


Fig. 8.—LUBRICATION
(Imperial and Pullman.)

correct adjustment being to tighten both end caps fully, releasing each of them until the first pin holes are reached.

GENERAL NOTES

(1) The bearings of the top link and also those in the spring eye are of the same construction, consisting in each case of flanged bronze bushes which are pressed in. These operate on hardened steel distance-pieces fitted over the actual bolts.

Upon considering this design, it will be seen that the length of the distance-pieces controls the end float of the bearings. This should be at least ·003 in. in each case, and in this respect it is interesting to note that by tightening the nut excessively the end float can be absorbed, causing the bearing to operate stiffly. Such conditions must be avoided, and it is advisable to check this end float by the insertion of a feeler gauge after the nuts have been tightened.

(2) The static spring camber can be tested accurately by the method described later in the steering angle and dimensions section, but the normal loaded position can be taken as being when the spring is flat or showing a slight reverse camber.

(3) The position of the lower leaf of the spring, being part of the steering geometry, must not be altered. Care must therefore be taken to replace the packing pieces in the correct position, should the spring be dismantled.

(4) The linkage system at all times must operate freely, and if any difficulties are experienced, such as excessive front-tyre wear, the first point to check is the freedom of these parts.

Steering Dimensions

The following are the steering angles and dimensions taken when the spring is in its static or normally loaded position.

Static Spring Camber, $\frac{3}{8}$ in.

This camber is measured by stretching a piece of string across the shackle-pin greasers, the measurements being taken from this piece of string to the lower face of the master leaf of the spring.

Castor angle	1° 30′
Wheel camber	2°
Slope of kingpin	7° 30′
Toe-in	$\frac{1}{8}$ in.

SUSPENSION ON SIXTEEN, SNIPE, AND SUPER SNIPE, 1939, ALSO FITTED TO 1938 SIXTEEN AND SNIPE

Upon examining this layout, it will be seen that the transverse leaf spring forms the lower link, whilst the upper link is a very rigid " wishbone " mounted on long bearings. Between the extremities of this upper and lower link the swivel pin is mounted.

Suspension Bearings

Screwed or threaded bearings are incorporated in the suspension, the pivots and the bushes being threaded so that a larger bearing area is obtained, and end float on the bearings eliminated.

In refitting these bearings it is important that clearance should be left so that the bearing can screw into the bush without the shoulders on the pivot fouling the ends of the bush. In the case of the " wishbone " bearings this is a simple matter, as the bushes are only clamped in the wishbones. When the car is in its loaded position, the clamping bolts should be slackened and the bushes turned until a balanced end clearance of approximately $\frac{1}{8}$ in. is obtained at either side.

The procedure is not quite so simple in the case of the screwed bush in the spring eye. In this case it will be realised that the end clearance depends upon the start of the threads in the spring eye bush, and these bushes should be pressed in to the spring eyes so that the start of the threads is at the 12 o'clock position. It will then be found, if care is taken that an equal end clearance is obtained with the spring in the fork at the bottom of the swivel pin. A slight readjustment of this matter may be necessary in a very few exceptional cases.

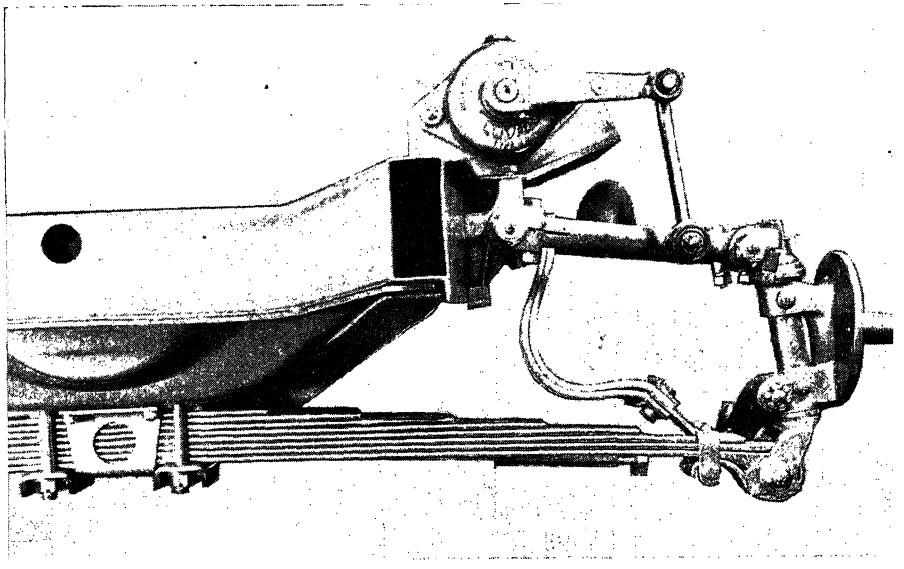


Fig. 9.—GENERAL VIEW OF SUSPENSION
(16-h.p. Snipe and Super Snipe.)

The transverse pin at the top of the steering kingpin is in the form of an eccentric, so that the wheel camber can be adjusted. In this respect it should be noted that the camber can only be upset by the replacement of either the chassis frame, " wishbone " or road spring, and thus the adjustment once obtained should not be altered unless contingencies of this nature are encountered. It will then be necessary to check and adjust the wheel camber, for which one of the many gauges marketed should be used.

Track Rod

This system of independent suspension is quite straightforward and entirely foolproof, except in dealing with the track rod and the position of the ball pins generally.

Upon examining the steering it will be seen that one track rod is considerably shorter than the other one, and it will furthermore be found, upon examining the layout more closely, that the ball pin on one stub axle is higher than the ball pin on the other stub axle. This is all a matter of careful geometry to ensure that steering reaction is not introduced by the movements of the front wheels over road undulations within the limits of the working range.

To explain this point, it is necessary to consider carefully the geometry

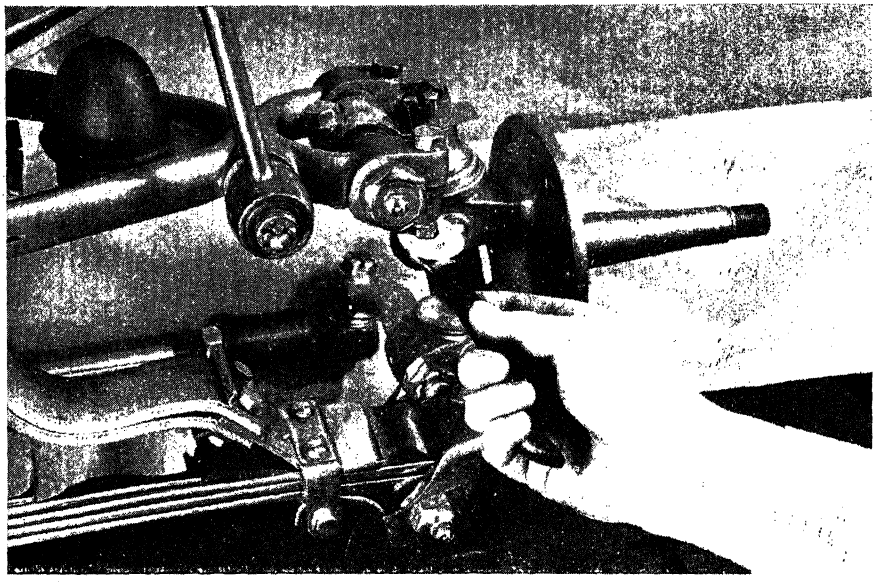


Fig. 10.—CLAMPS HOLDING BUSHES
(16-h.p. Snipe and Super Snipe.)



Fig. 11.—WHEEL-CAMBER ADJUSTMENT]
(16-h.p. Snipe and Super Snipe.)

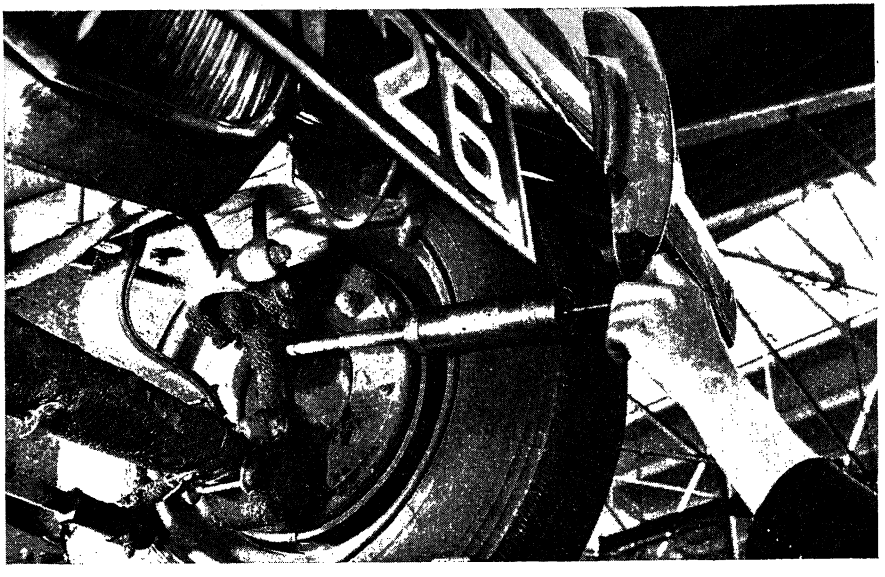


Fig. 12.—LUBRICATION
(16-h.p. Snipe and Super Snipe.)

as a whole. The upper link is considerably shorter than the lower link. This is so that the wheel track scarcely varies with the wheel movements.

To emphasise this fundamental point, it should be pointed out that, while the spring eye is moving outwards through a wide arc, which would tend to increase the track, the outer bearing of the " wishbone " is also moving outwards through a shorter arc, and this compensates for the movement of the spring eye, and, whilst the track remains almost constant, the wheel camber is altered slightly by the vertical wheel movements.

It will be seen from the above that in the stub axle assembly we have two points moving through two arcs of different radii. At any point between the upper and lower bearings of the stub-axle assembly, an arc of intermediate radius is described ; thus the ball pin is set on the stub axle so that it moves through an arc, the radius of which is the same as the track rod coupled to it. Track rods could, therefore, be used of any length which is shorter than the lower link, i.e. the leaf spring, or longer than the upper link, always providing that the centre about which it moves is definitely determined. This is the case with the short track rod.

The important point about the above is that an alteration to even such a small matter as the rake of the steering column will considerably upset the steering layout of this suspension, and if any cases of difficulty are experienced, these ball-pin positions must be checked up in accordance with the table of dimensions given.

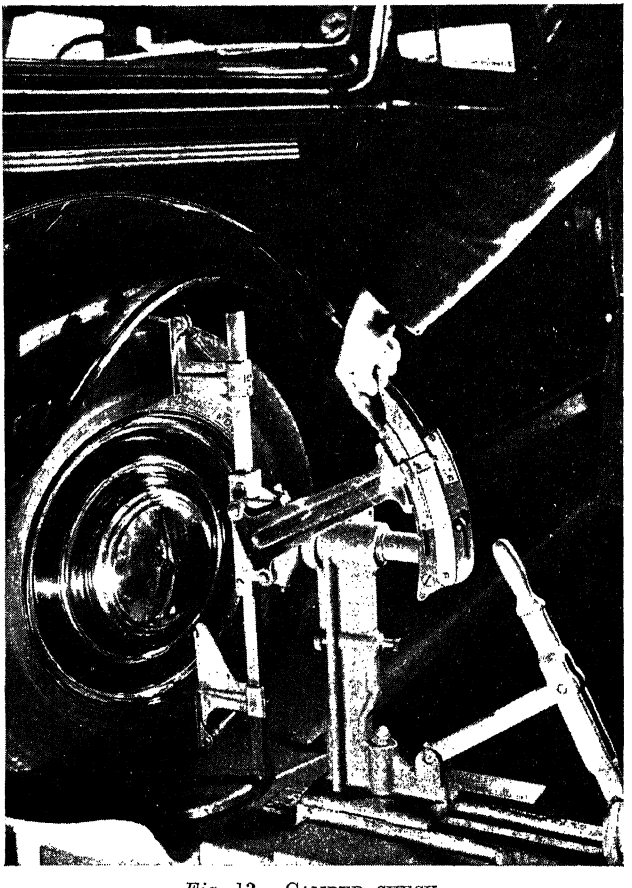


Fig. 13.—CAMBER CHECK
(16-h.p. Snipe and Super Snipe.)

The ball pin for the long track rod is mounted low down on the stub axle, and thus it describes the longest possible arc.

The ideal length of the long track rod would be the radius of this arc, but the slight difference between this radius and the length of the longer track rod is altogether insufficient to introduce any steering reaction, so, by remarkably clever design, extra weight and moving parts which would normally require attention have been eliminated.

The Build-up of the Swivel Pin

The build-up of the swivel pin is as follows :

The knuckle at the top of the pin is secured against a shoulder by the nut. At this point a hardened-steel thrust washer is interposed. On the stub axle itself a similar thrust washer is pegged, and floating between these two hardened-steel surfaces a bronze thrust washer is incorporated. The stub axle itself has two bearings and is bushed in the normal manner. Between these bearings a piece of tubing is fitted which covers the portion of the swivel pins which would be exposed. This tubing is nipped between the swivel pin bushes.

Lubrication

In the screwed bushes considerable clearance is left for the circulation of the lubricant. This clearance is absorbed on the V-threads when

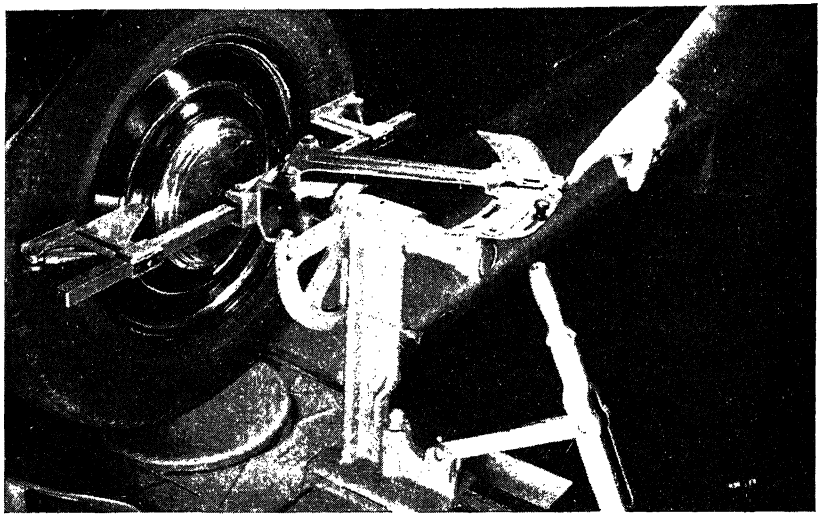


Fig. 14.—TOE-IN CHECK
(16-h.p. Snipe and Super Snipe.)

weight is applied to the bearings, and thus the sloppiness in these which is apparent when they are not under load is no detriment to the action of the bearings in proper use. Owing to this provision, adequate quantities of lubricant are stored in the bearings themselves, which do not require any attention except at intervals of 3,000 miles.

Steering Angles

Given below are the various angles in this assembly, and it should be noted that the wheel camber has a very considerable effect on tyre wear, and this should be checked with great care whenever trouble of this nature is experienced. As has already been explained, the wheel camber varies with the flexing of the front spring, so that before these angles are checked the front spring itself must be loaded to a definite position, which is determined by measuring the spring camber, i.e. the distance between the centre line of the spring eyes and the lower face of the spring at the centre. This distance should be $\frac{1}{2}$ in. Furthermore, as the majority of camber gauges operate on the spirit-level or plumb-bob principle, it is obvious that the car must be level before these gauges can give accurate readings.

Subject to the above remarks, the steering angles are :

Wheel camber	1°
Inclination of swivel pin . .	10°
Castor angle	2° 52′

Position of Ball Pins

If at any time, through accidental damage, the position of the ball pins has been altered, it will be appreciated from the foregoing remarks under the heading of " Track Rod " that this must be corrected accurately if the suspension is to prove satisfactory. The following dimensions determine the correct position of the ball pins :

Off-side Ball Pin on Steering-box Arm with Wheels Straight Ahead

From centre line of spring to centre of ball	123 mm.
From top of frame to centre of ball	236 mm.
From centre line of chassis to centre of ball	9·7 mm.

Ball Pins on Side Steering Arms

Nearside—centre of ball on centre line of spring eye.
Offside—centre of ball 19 mm. above centre line of spring eye.

SPECIAL POINTS TO BE WATCHED WHEN REPAIRING ALVIS CARS

THE PROPELLER SHAFT, REAR AXLE, BRAKES, AND STEERING

By F. C. BROWN

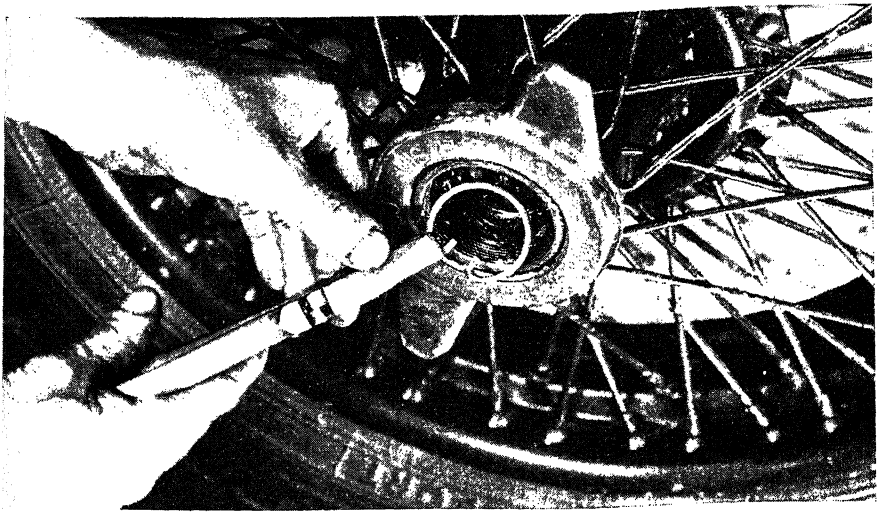


Fig. 1.—REMOVING REAR-AXLE SHAFTS
Extracting spring ring before removing axle shafts.

PROPELLER SHAFT

NO lubrication is called for in the needle roller-bearing propeller shaft joints, but in the event of joint failure it is recommended that the complete shaft with both universals be removed and returned to the works or service depots. A service shaft can be supplied.

Dismantling and Assembling

Should it become necessary to dismantle the propeller-shaft at the front end, there is no need to uncouple the flange bolts. A screw-on collar

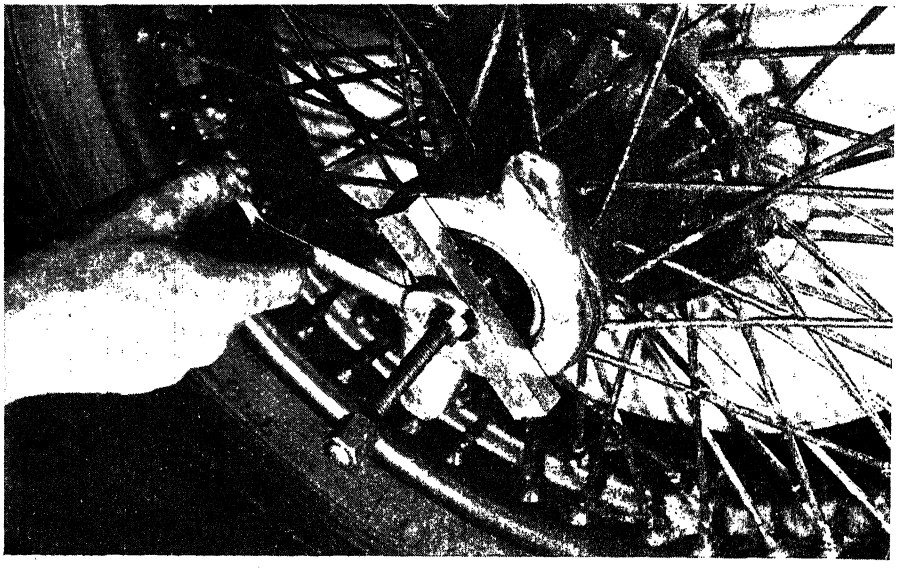


Fig. 2.—REMOVING REAR-AXLE SHAFTS
Positioning rear-axle shaft extractor.

is attached to the front universal joint, and if this collar is unscrewed, provided the shaft is freed at the rear end, it can be pulled clear, leaving the joint attached to the gearbox. When replacing, insert the splined end so that the arrow on the shaft registers with the arrow on the housing.

REAR AXLE

Speed 25, 4·3-litre, and Crested Eagle

The Speed 25, 4·3-litre, and Crested Eagle models have rear axles of the fully floating, spiral-bevel type, the load being taken by steel tubes forced into the aluminium casing under pressure. Dismantling is not complicated, providing the correct sequence of operations is followed.

Excessive Play in Transmission

Before suspecting the differential unit if there is excessive play in the transmission, examine first the clutch-shaft joints, propeller-shaft universal, and wheel driving plates. The latter are corrugated plates on to which the corrugated hub of the road wheel proper is mounted before being secured by the chromium-plated knock-on wheel lockers. It is important that the latter be properly tightened (offside left-hand thread; nearside right-hand thread), but make sure that the splines or corrugations bed firmly. A good coating of thick grease is recommended.

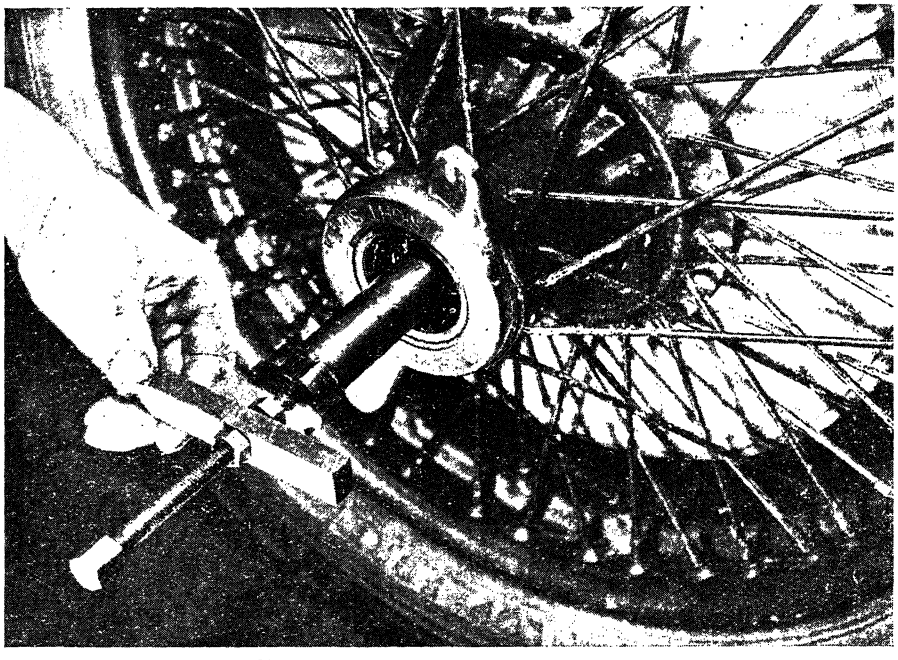


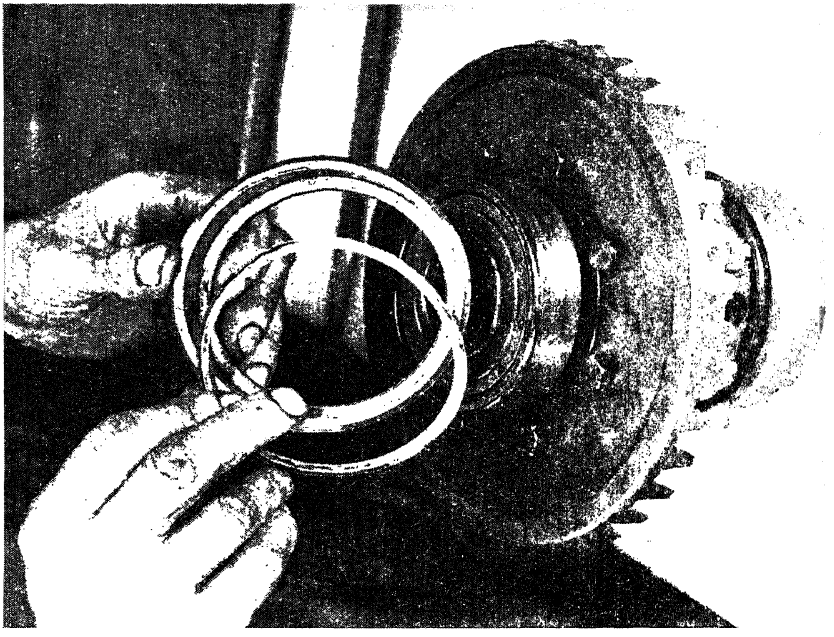
Fig. 3.—REMOVING REAR-AXLE SHAFTS
Withdrawing axle shaft with aid of extractor.

Dismantling Hubs

To dismantle the hubs, first remove the road wheels and take out the grease caps. Next detach the corrugated wheel plate, also the brake drum by extracting the three countersunk screws. Note that the driving studs do not retain the brake drum, which slides off them. The judicious use of a hide hammer may be necessary if the drums have not previously been disturbed. Now the brake shoes may be removed by taking out the spit pins securing the shoe pivot pins ; next the hub cover, which holds the inner bearings ; and finally the hub itself, with the aid of a suitable extractor. This should leave the ball bearing and inner race of the roller bearing on the axle tube.

It is necessary, when reassembling, to ensure that the nut holding the hub bearings on the extension of the axle tube is securely locked in position. Watch also the offside parts with left-hand threads—hubs, grease caps, etc.

In all cases it is necessary to withdraw the axle shafts before the differential can be extracted, and in the case of the 12/70 this means complete hub assembly also. On all other models, however, the removal of the road wheels and grease caps reveals the ends of the axle shafts,





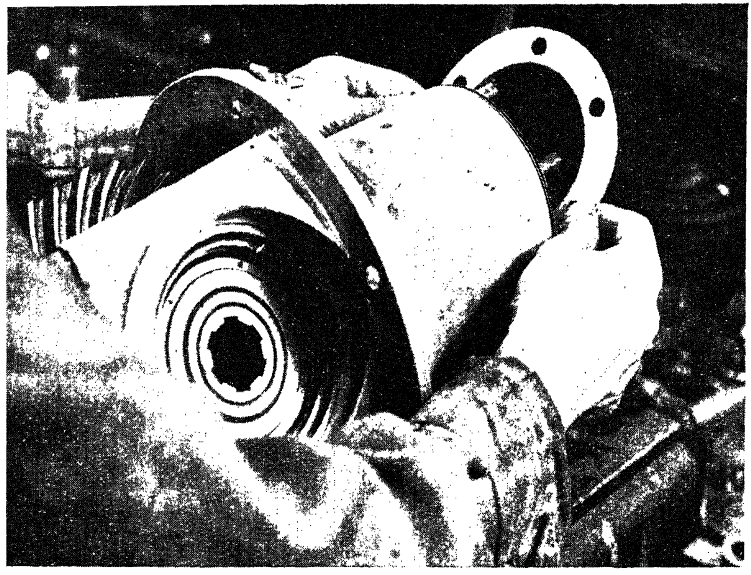


Fig. 5.—REAR AXLE
Sideways adjustment of crown wheel, using brass shims.

Fig. 6.—REAR AXLE
Shimming bevel pinion to correct fore and aft play.

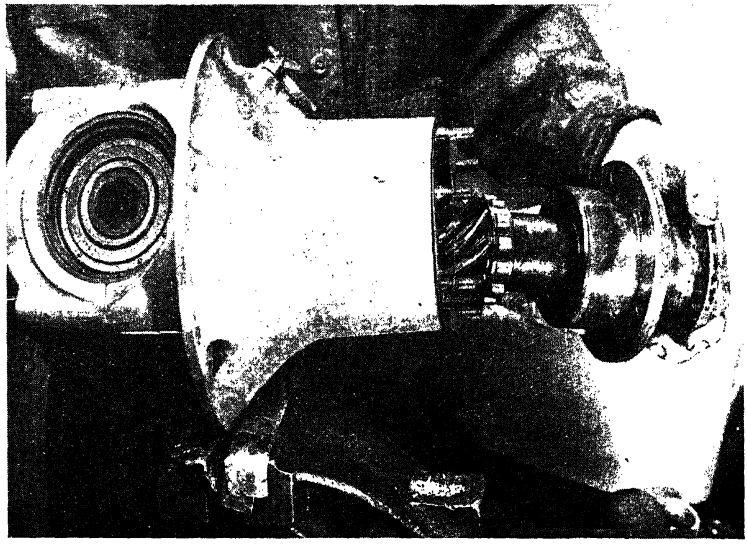


Fig. 4.—REAR AXLE
Sideways adjustment of crown wheel, showing brass shims.

Fig. 7.—REAR AXLE
Reassembling bevel pinion assembly.

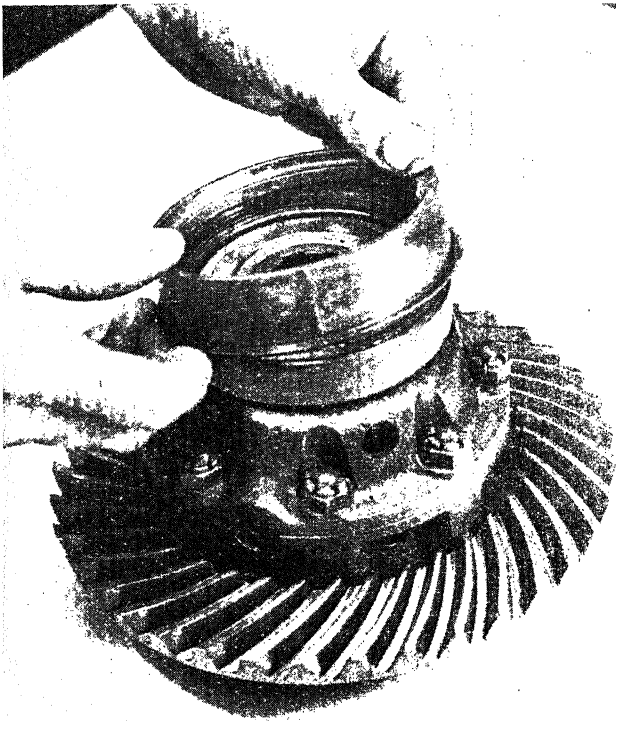


Fig. 8.—REAR AXLE
Removing differential bearing housing.

which are drilled and tapped to take a suitable extracting bolt. The replacement of these shafts requires care. They should be turned slightly so that the splines register with the differential sun wheel—a few taps with a hide mallet is all that is required.

Do not Interchange Axle Shafts

Axle shafts are marked right-hand and left-hand, and must not be interchanged, as they have oil-retaining scrolls machined in them, and reversing the shafts means that oil will be guided from the differential instead of back to it. This does not apply to the 12/70 and Silver Crest types, but it is not recommended that the shafts be changed over unnecessarily.

Rear Hubs on Silver Crest

For the Silver Crest series hub dismantling is carried out as follows :

(1) Remove the road wheels.

(2) Disengage the tab washers and remove the hub grease caps.

(3) Extract the three countersunk screws and remove the brake drum.

(4) Remove the five wheel-stud nuts. They are to be found at the back of the hubs.

(5) Affix cover-plate extractor to the hub by means of the tapped holes provided and extract the hub, exposing the bearings.

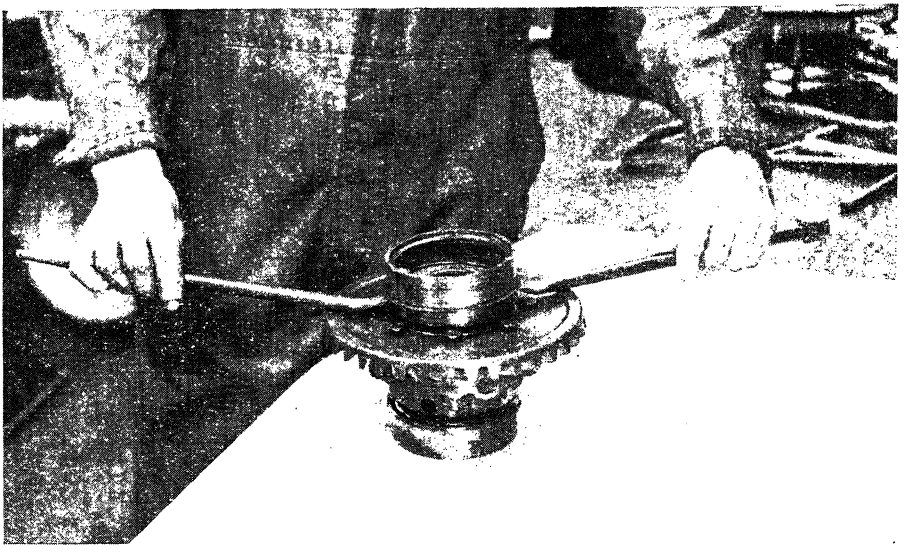


Fig. 9.—REAR AXLE
Extracting ball race from differential assembly.

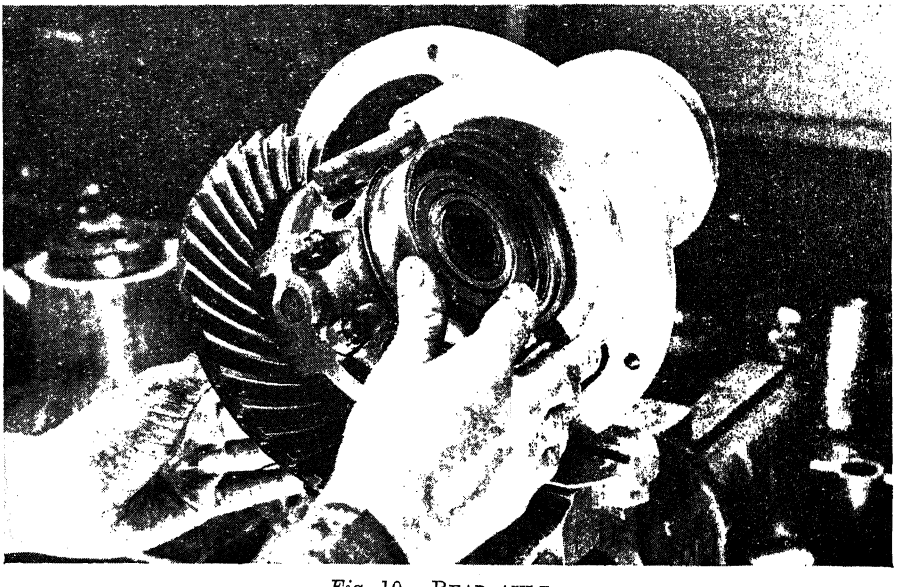


Fig. 10.—REAR AXLE
Replacing differential unit in differential housing.

Differential Units on All Models

To replace all differential units proceed as follows :

(*a*) Remove axle shafts.

(*b*) Lower the rear end of the propeller shaft by undoing the bolts which hold the universal joint to the bevel-pinion flange.

(*c*) Unscrew the nuts holding the front housing to the main axle casing.

(*d*) Withdraw the housing, together with the pinion and differential gear.

A receptacle should be available to catch the oil from the axle casing.

Adjustments fore and aft and sideways to the meshing of the pinion and crown wheel are made by means of brass shims of various thicknesses.

A point to note in respect of the 12/70 is that excessive end float on the rear-axle shafts may be taken up by removing the shims between the wheel-bearing housing and the brake carrier plate, but the hub and brake drum must first be extracted. When reassembling see that the shafts still have *some* end float. Between ·003 in. and ·006 in. is ideal.

Another note regarding the 12/70 might usefully be inserted here. Adequate lubrication of the *front* hub assemblies is really important. Cases have been brought to light where shortage has caused bearing failure. To prevent this, fully charge the hubs with grease, not oil, when assembling, and give a smaller charge at intervals of 5,000 miles. Should bearing failure have occurred from dryness, examine also the stub axle to see if there are traces of scoring or if the stub is out of truth. Replace if the slightest doubt exists about its condition.

BRAKES

Adjusting Brakes on 4·3-litre, Speed 25, and Crested Eagle

Although the wing adjusting nuts on the 4·3-litre, Speed 25, and Crested Eagle systems are useful in enabling quick and easy adjustment to be made generally, compensation between front and rear and balance between nearside and offside brakes can only be caused by individual adjustment on each of the four brake cables. This adjustment, which is necessary at regular intervals, is made as follows :

(1) Jack up the car with all four wheels clear of the ground.

(2) Slacken off the central wing-nut adjusters to the fullest possible extent.

(3) Recentre the front brake shoes by turning the eccentric stops in the front brake cover plate. These will be found immediately above the steering pivot. These stops are fitted with a pointer which moves in between two lines marked "off" and "on." The stops should be slackened back until the wheels just spin freely without the shoes touching the drum.

(4) Pull on the hand brake lever one notch.

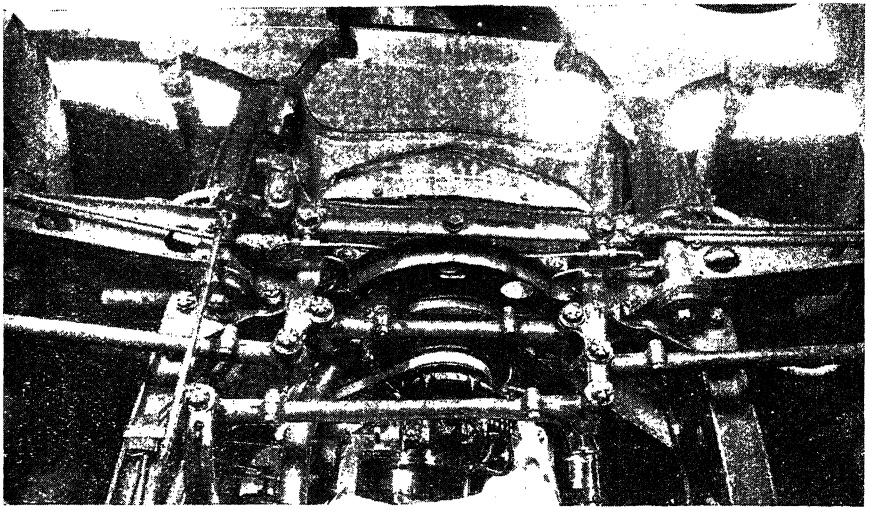


Fig. 11.—STEERING-ROD LAYOUT
View from underneath Silver Crest.

(5) The two front brake-cable adjusters are now unscrewed until the front brake shoes just grip the drum, so that a little effort is necessary in order to turn the wheel. The locking nuts will, of course, have to be slackened off before the adjusters can be manipulated, and should be resecured on completion of the adjustment.

(6) Pull on the hand brake lever two more notches.

(7) Recentre the rear brake shoes as for the front.

(8) Adjust both rear brake cables as for the front by means of the nuts provided on the cable extremities.

(9) With all brakes off ensure that the wheels are free to rotate with no brake shoes rubbing.

Servo Assisted Brakes

Latest Speed 25 and 4·3-litre models have Alvis brakes servo assisted. Note that the pull rod of the servo motor should be adjusted until the pedal head tends to be drawn away from the floorboard. The valve has two definite motions which can be felt by hand, one to take up clearance and close air port, the other to open vacuum port. The valve should be adjusted so that there is about $\frac{3}{32}$ in. to move out of the total $\frac{1}{4}$ in. available before the vacuum valve opens.

Flexible gaiters on both servo and valve unit must not be damaged, as ingress of dirt must be prevented if the vacuum brake is to function satisfactorily.

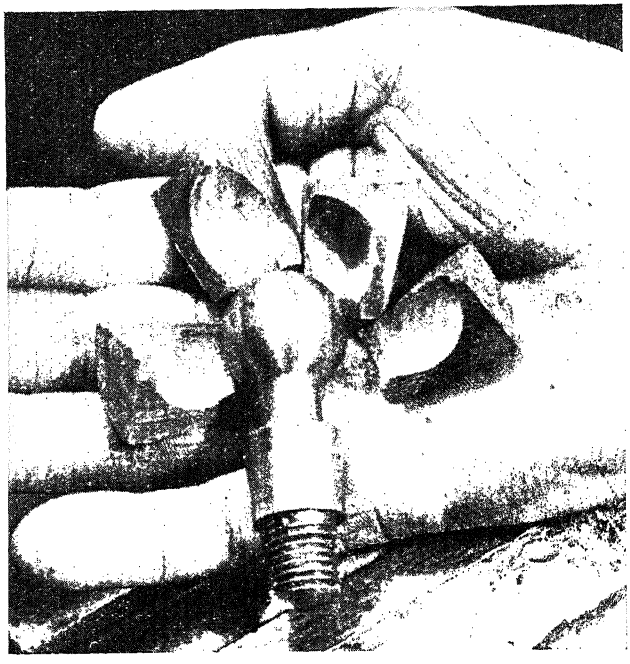


Fig. 12.—WEARING PARTS OF STEERING JOINT
Showing the steel ball pin and split lignum vitæ bearing.

Bendix Brakes

On the 12/70 and Silver Crest models Bendix brakes are standard, and providing the brake-operating mechanism works freely the only adjustment necessary is as follows: Screw up the shoe adjuster until tight, by rotating in a clockwise direction, and then slack back three-quarters of a turn, that is, five notches or clicks.

It will be observed that there is no central adjuster, and adjustments must be made at the individual drums. When brakes need relining, apply to the Works for genuine Bendix replacement shoes (this does not apply to Alvis brakes, as with them it is recommended that the original shoes be relined with standard die-pressed linings obtainable from the works or service depots). A further note regarding Bendix brakes—do not interfere with the operating mechanism by shortening the rods or cables, but do keep the compensators working freely by spraying with oil occasionally, and grease the working parts well with graphite grease.

Braking Noises

When in new condition Alvis brakes have a tendency when applied to shriek, which terminates in a groan as the car is brought to a standstill. Although the noise is harmless and will eventually wear off, it can be eliminated by filing the friction surfaces of the linings at each end to form a chamfer of about $\frac{3}{4}$ in. In addition, the sides of the linings should be filed to obtain a pointed effect.

STEERING

Adjustment of Marles Steering

All models with the exception of the Silver Crest range are fitted with Marles steering, there being generally two adjustments—between

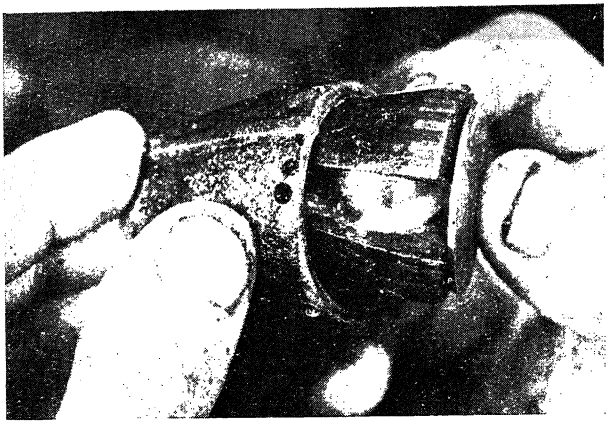


Fig. 13.—THE FIRST STAGE IN ASSEMBLING STEERING-ROD JOINT

the roller and cam; and of the bearings between which the cam revolves. It is, of course, necessary to remove the steering unit from the chassis.

It will be noted that the roller is mounted on an eccentric bush or distance-piece which is carried by a bolt and nut. The latter has its centre part serrated, being a fit in the serrated hole in the rocker shaft farthest away from the head of the bolt. By means of these serrations, therefore, the bolt ties together the positions of the distance-piece and rocker shaft. As the distance-piece is made with the outside diameter eccentric, the roller assembly (mounted on the distance-piece) moves in relation to the rocker shaft by rotating the bolt, and in this manner the roller assembly can be raised or lowered away from the cam. After the rocker shaft nut and washer have been removed the rocker-shaft bolt should be withdrawn until the serrations are just free of the rocker-shaft serrated hole—that is, about $\frac{3}{8}$ in. Turn the bolt one or two serrations in a clockwise direction for giving deeper engagement between roller and cam.

End play of the cam bearings may be taken up by removing some of the thin shims between the box casting and the column support. The shims between the casting and the bottom plate should on no account be taken



Fig. 14. THE SECOND STAGE IN STEERING-ROD JOINT ASSEMBLY

Inserting spring and adjusting plug.

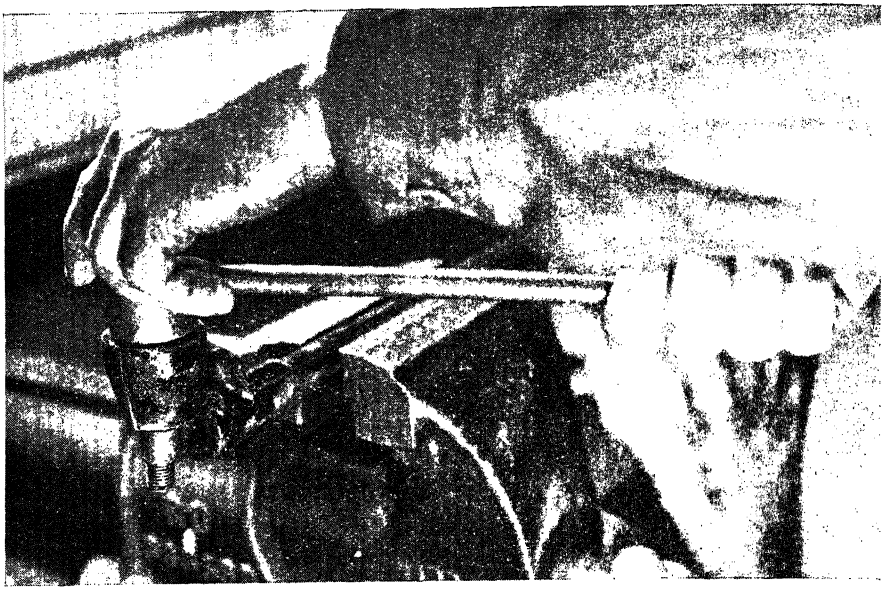


Fig. 15.—REASSEMBLING STEERING JOINT ON TRACK ROD

away. In the case of steering types L. 7 and R. 7 Marles gears there is provided an adjusting screw to take up excessive end play in the rocker shaft. It is merely necessary to release a locknut to gain access to the adjusting nut.

Burman Douglas Steering

The only adjustment recommended on the Burman Douglas type of steering used on the Silver Crest cars is a slight tightening of the ball race at the top of the column, and then only after a long period of service when the balls may have buried themselves in the track of the races.

Checking Up Self-adjustable Steering Joints

Every car has self-adjustable steering joints of the split conical lignum vitæ bush type. They should be checked for tightness periodically, and the wood bearings renewed if necessary. On older cars carefully examine the ball pins also, and remember that on the cars having independent front-wheel suspension there are *eight* separate ball-joint assemblies which require attention.

Wheel Wobble

Should trouble with wheel wobble or tramp occur, check first the condition of these lignum vitæ steering joints, then the tracking of the front wheels. On the Silver Crest and 12/70 models they should be set

to toe-in approximately $\frac{1}{8}$ in., but the Speed 25, 4·3-litre, and Crested Eagle models must have the wheels set to toe-out between $\frac{1}{8}$ in. and $\frac{3}{16}$ in. Watch also the tyre pressures, and replace worn outer covers.

If the difficulty persists, attend to the balancing of the front wheels; changing the nearside to offside or front to rear may give the desired result on the Silver Crest or 12/70 cars. On the larger models, wheel balance has been found to have a real bearing on wheel wobble, and wheel balance-weights, consisting of a number of flat balance-weights bolted inside cups to the inside of the wheel rims, are fitted as standard. The procedure for rebalancing is as follows:

(1) Jack up the front of the car, and ensure that the brakes are free.

(2) Test to see if there is a tendency for the wheel always to revolve so that a heavy portion falls to the six-o'clock position.

(3) If this does occur, remove the cup from the balance-weight assembly which is nearest diametrically opposite to the heavy portion of the wheel, and add a weight or weights to restore balance.

(4) Repeat the process until perfect balance is obtained. It may, of course, be necessary to completely reweight the three assemblies to effect this.

These cars are also provided with a front harmonic stabilising bumper, and if all other efforts to eliminate wheel wobble or tramp fail, variation of the weights in the end-cap assemblies should be tried. Usually heavier chromium-plated weights will do much to help, and suitable ones can be obtained. It must be made clear, however, that the bumper must not be interfered with in the ordinary way and certainly not until all the points already mentioned under "Steering" have been covered.

A final point regarding Marles steering units. Should a new cam-roller assembly be fitted on the L. 7 steerings, the replacement will probably be of a modified pattern although strictly interchangeable. It is important to see that the new cage is assembled correctly, and to do this the cage assembly should be fitted on to the coned inner race on the cam, and then the outer race assembly over them. The cage assembly should not be assembled with the outer race.

Shock Absorbers

Silver Crest and 12/70 models have ordinary Luvax hydraulic shock absorbers, for which internal adjustment is provided. Remove the filler plug and turn adjuster in a clockwise direction to tighten. The 4·3-litre and Speed 25 cars are fitted with finger-tip control mechanism. The over-riding control is provided by a spill valve situated on the engine side of the dash, and which enables the pressure generated by the independent pump to be discharged into a reservoir at varying rates depending on the position of the spill valve, which has a graduated rate of discharge into the reservoir, controlled by the lever on the dashboard.

These shock absorbers are often abused. When the car is heavily loaded and at high speeds the control must be turned to maximum, or the springs, which are designed to give the best comfort at all speeds, will have to do more than their share of work and bottoming may result. Otherwise the shock absorbers need little attention save the refilling of the absorbers themselves with official Luvax fluid (this applies to all Luvax shock absorbers). Topping up to a maximum high level of $\frac{3}{8}$ in. from the top at intervals of 8,000 and 10,000 miles is all that is necessary. In the spill-valve reservoir a winter grade of engine oil should be used—not the shock-absorber fluid.

Should there be a tendency for the front shock-absorber bolts on the 1938, Speed 25, and 4·3-litre cars to work loose, apply to the works for a supply of special nickel-chrome bolts, and refit to the frame. With the new bolts a plain washer should be fitted under the bolt head on the inside of the chassis number, and the nut should be split-pinned after tightening hard.

12·70 Rear Springs

When carrying out replacements of 12/70 rear springs it is necessary to remove the metal cover from the body valance. This cover is secured by six wood screws, and when it is removed the wooden valance will be found to contain a large aperture, through which a box spanner can be inserted, and the rear-spring front shackle pin removed. It is often thought necessary to remove the whole shackle bracket, but if the foregoing procedure is adopted this will not be necessary.

Roof Rear Drain Tubes

These tubes are carried from the rear of the roofs down through the rear quarters and protrude through the rear-wheel arches. In some cases the rubber tubings are left a little too long so that they foul the tyres when the car rolls or is heavily laden. The resulting noise can be very alarming—something between a loud roar and a screech, but a remedy is easily effected by cutting off the rubber tubes by about 2 in., which will give ample clearance. It is a simple point, but one might search a long way without being able to locate the cause.

Windscreen Water Leaks

If rain should leak in behind the windscreen rubber it is liable to pile up at the bottom and work through the wiper mechanism or the windscreen fillet. By punching or drilling one hole on either side of the screen rubber at the bottom corners, any trapped water will be released and drained away. The holes should be approximately $\frac{3}{32}$ in. in diameter and $\frac{1}{4}$ in. from the outside edge of the rubber. They must, of course, be positioned at the lowest points on either side of the windscreen.

CHASSIS LUBRICATION

Some Alvis chassis have incorporated an automatic lubrication system operated by the action of the clutch pedal. A pump is mounted on the engine sump from which it obtains its oil-supply.

The only adjustment which is likely to need the attention of the repairer is that for increasing or decreasing the supply from the pump. There are two outlets and two adjusters on the pump, and once it is decided which series of points requires attention the appropriate adjuster may be turned in an anti-clockwise direction to decrease the rate of flow, and vice versa. One and a half turns will reduce the rate of flow by approximately one-half, but care must be taken to see that all the points fed by the system are receiving adequate lubrication.

It is important to check up on any central lubrication system at periods of approximately one month, and if oil is not reaching any particular point or points, these should be dealt with before damage is done to the respective parts. It is not good engineering to leave a centrally lubricated bearing alone until it starts to squeak—preventive service is an important matter. Cars which are pressure-washed very frequently are liable to get water and mud forced in through such parts as king pins and shackle pins. When a car is so washed frequently, extra central lubrication should be the rule.

SERVICING CHEVROLET CARS

FRONT-WHEEL SUSPENSION AND BRAKES

By N. A. MOORE

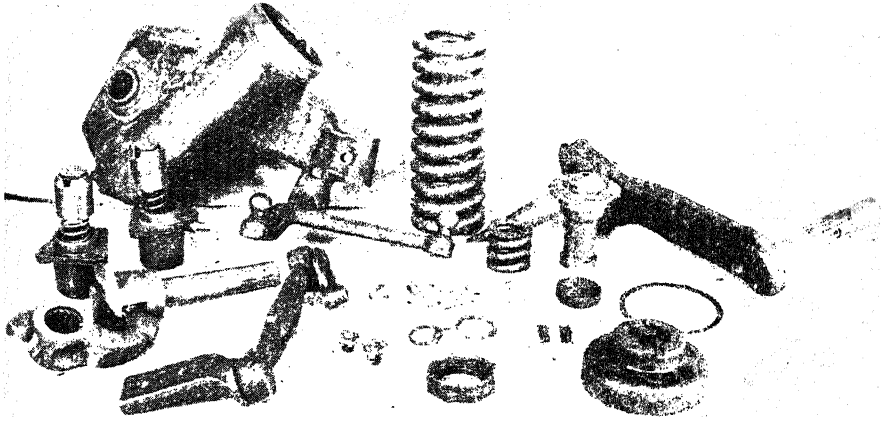


Fig. 1.—PARTS OF CHEVROLET KNEE-ACTION ASSEMBLY

KNEE-ACTION UNITS

Maintenance

THE fluid levels in these units should be checked every 750 miles, and the correct amount of fluid added to bring the level up and even with the square filler plug which will be found on the front of the housing. Only the correct fluid is to be used in this instance, which will be Wakefield Shockol. Most Chevrolet dealers stock this fluid.

Lubricating nipples should be regularly run over to ensure that all working parts are thoroughly greased to reduce friction and prevent wear, and particularly radius-arm nipples, to expel any water that may have penetrated into the working thread ends. This operation must be carried out with a hand grease-gun. High-pressure lubrication will blow out swaged plugs on radius arms.

In checking the knee-action unit, the car should be jacked up, and suitable jacks placed under the king-pin carrier for safety. The front wheels can then be taken off and drums removed. This will allow a proper check to be made for wear on the brake carrier flange bushings.

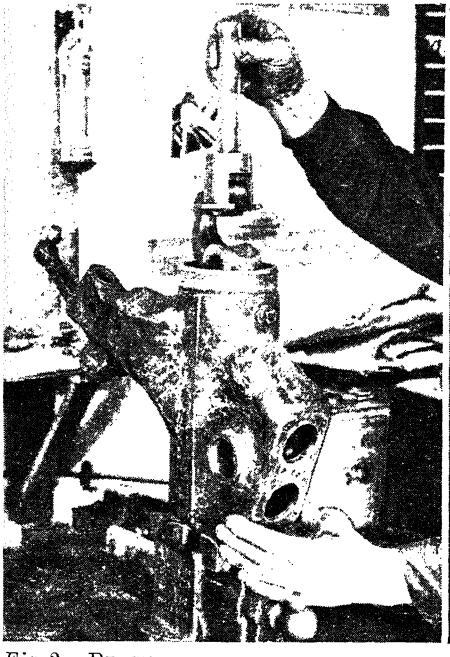


Fig. 2.—REASSEMBLING KNEE-ACTION UNIT

Fixing knee-action main spring into position.

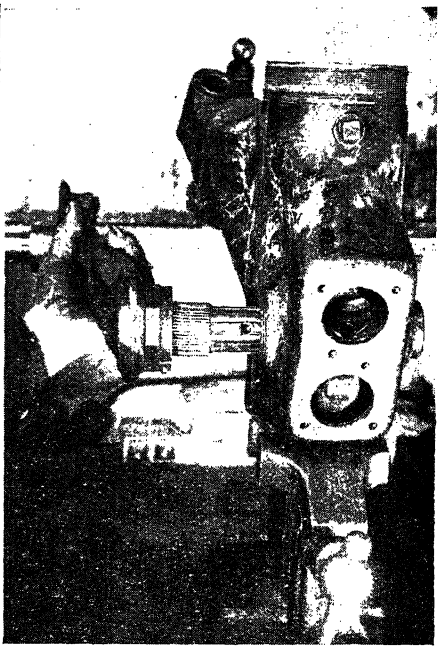


Fig. 3.—REASSEMBLING KNEE-ACTION UNIT

Wheel-bearing spindle going into position. Note the needles held together by means of an elastic band.

If worn, they should be replaced. It is important that the inner and outer wheel bearings be kept free from grit, and before replacing they should be thoroughly washed.

Careful check should be made of all ball and socket joints, steering-arm nuts, and king-pin support bolts on the chassis frame.

The steering gear also should be checked at the same time to see that the adjustments are correct.

Knee-action Repair

In order to check the height of the knee-action unit, the measurement should be taken from the bottom of the king-pin support to the bottom of the brake flange plate. This measurement should be $4\frac{7}{8}$ in., plus or minus $\frac{1}{8}$ in., and both sides should be equal within $\frac{1}{4}$ in. If this dimension is found to be incorrect, remove the setscrew retaining lockplate ; the inner plug is then to be wound down to increase height of the car, or released to reduce height of car. In doing this, a margin of safety is to be observed. This plug should not be wound down to show more than three threads of the outer cap.



Fig. 8.—ASSEMBLING KNEE-ACTION UNIT
Fitting main spring guide into position.



Fig. 9.—PUTTING MAIN SPRING CAP AND ADJUSTER IN POSITION
Tension of spring can be adjusted by means of screw at top.

necessary to renew the complete unit; there are several component parts, comprising housing and cap, inner spring, upper spring assembly, spring guide, adjusting plug, complete shock-absorber units or component parts.

Remove the $\frac{5}{16}$-in. setscrew from the adjusting plug on the top of knee-action unit, and screw out the main spring adjusting plug. This relieves the tension on the main spring centre guide and allows safe removal of the housing cover.

Remove the housing cover, then lift the main spring upper seat assembly out from the housing. Lift out the large outer spring. If a spacer is found under this spring, it must be replaced if the old spring is used when reassembling, but if a new spring is installed, discard the spacer. Remove the inner rebound spring from the lower spring seat at the bottom of the housing, empty out the shock insulation fluid into a clean pail or can; loosen shock-absorber cap screws.

Care should be taken when removing shock-absorber units, as each unit contains a strong valve-retaining spring. The wheel support arm

shaft cannot be withdrawn until compression and rebound units have been removed. Then will be seen the cheese-headed locking screw. To remove this screw, a heavy screwdriver is required. When screw is extracted, the next operation is to loosen locking grub-screw on gland nut. Then with the special gland-nut spanner undo the nut until it clears the threaded boss on knee-action body. It will be noticed that while undoing the nut, the nut will be with drawing shaft. With one hand under the gland nut, withdraw shaft and catch needle-roller bearings.

New parts can be fitted, and the above operation can be reversed for reassembly.

After assembling the unit, it is advisable to bounce the car up and down several times before taking the measurements stated in the early paragraph of this article, and also the radius-rod brackets should be allowed to take up their best position before locking in place, after which the two ¾-in. S.A.E. setscrews should be securely tightened and locked with the locking plate. Then give the car a good road test, for preference over rough roads, to check the action of the front wheels and also to get the fluid circulating through the shock absorbers to expel all air. After testing the car, examine the radius-rod brackets and see that they are thoroughly secure.

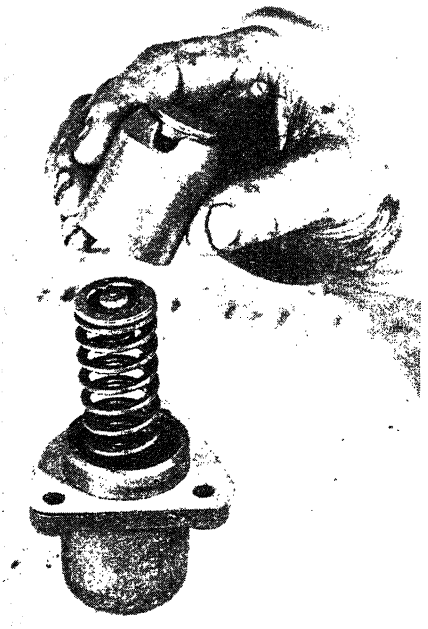


Fig. 10.—ASSEMBLY OF SHOCKER AND VALVE

To Remove Knee-action Units

To remove or replace knee-action units, proceed as follows : Jack up car on suitable jacks, remove front wheel and drum. Disconnect radius arm, by removing the two ¾-in. S.A.E. setscrews, on the bottom of knee-action body, and remove lockplate. Disconnect radius arm, turn the unit outwards on full steering lock, and remove brake-carrier assembly, taking care not to twist or damage rubber brake-fluid pipe. Place this assembly on a suitable wooden block to take the weight off the rubber connecting pipe. Next remove the cotter, locating the king pin. Remove the dust cover, to be found on top of the king-pin support yokes. Remove the spring-retaining rings on the top and bottom of king-pin yokes. Then drill a ¼-in. diameter hole through top plug. Insert a

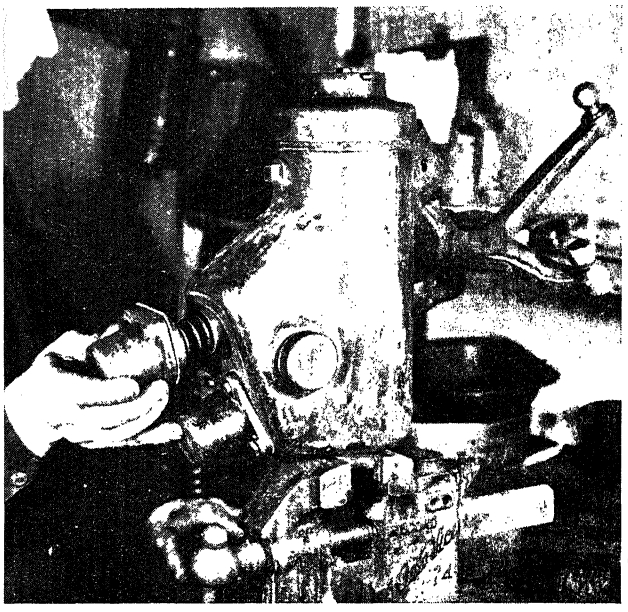


Fig. 11.—ASSEMBLING KNEE-ACTION UNIT
Fitting shockers into body.

drift and drive out bottom plug. Reverse the action and drive out top plug. Now drive the king pin out of support bearings, and carefully remove knee-action units, taking care not to damage the thrust race. Look out for any shims that may be found on thrust race. Now remove the top and bottom floating king-pin bushings, and check for wear.

Whilst these parts are dismantled, carefully check the bores in the king-pin support yokes. Should these be found loose, it is advisable to fit over-sized bushes. A special reamer is supplied for this purpose, and is available from Chevrolet stockists.

A careful note must be made that the reamer is not forced, and the reamer should be liberally lubricated, and rather allowed to feed by its own weight.

The lower yoke can be reamed in the same manner as the upper unit, but the over-size pilot sleeve must be used in this instance.

Reassembling the Knee-action Unit

To reassemble the knee-action unit to the king-pin support the following operations are necessary : Start inserting the king pin at the bottom, being sure that the longest end of the king pin from the slot is at the top, and that the slot in the king pin lines up with the lockpin hole.

Tap the king-pin thrust bearing into place, using a soft lead hammer. The king-pin thrust bearing must be assembled between the upper support boss and the top of the spring housing or steering knuckle ; make sure that the dust-shield side is towards the top.

Check the end play between the spring housing or steering knuckle with a feeler gauge, and if this is over ·006 in., insert a steel shim of the correct dimensions to overcome.

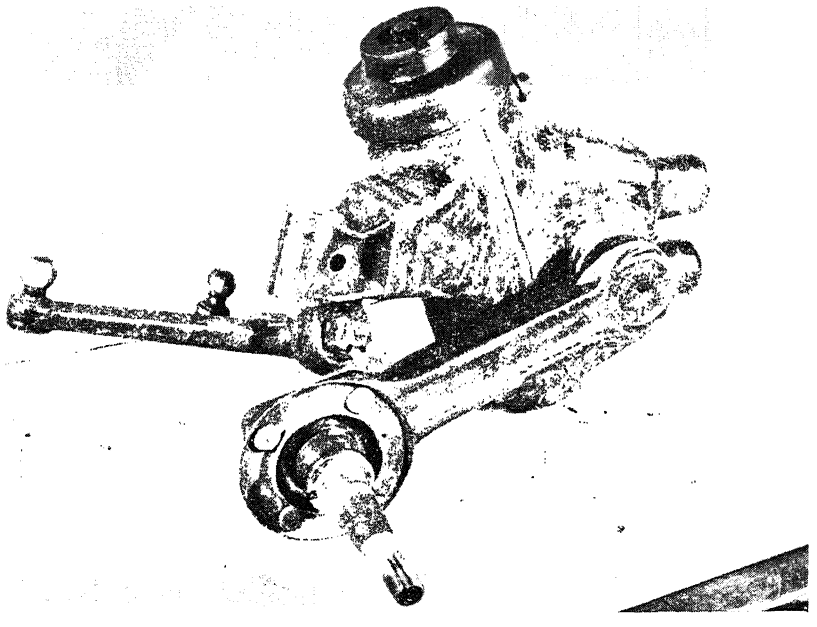


Fig. 12.—COMPLETED KNEE-ACTION UNIT

Assemble the brake flange plate to the wheel-carrier spindle, smear the cork gasket with heavy oil or grease and install on the spindle ; assemble the bearing spacer to the brake flange plate, so that the tongue on the spacer engages the slot in the spindle, and assemble the inner bearing cone. Fit the front wheel to the spindle and reassemble in the usual manner. Great care should be taken in connecting the radius rod to the knee-action housing. Screw the radius-rod bracket up tight on the radius rod. Then bring the radius rod straight up without moving it to either side. Loosen the bracket just sufficiently to line up with the boss on the front-spring housing. Then place in position on the boss and assemble the lockplate and tighten the two radius-rod brackets to the housing bolts securely.

Place the knee-action body in the vice, using the block on the bottom of housing as a means of holding. Care should be taken that the unit is clean, and that the bearings for the needle rollers are not damaged in any way.

The gland-nut bearing on the wheel support spindle arm should be checked for any step wear, due to the action of the arm. This should be dressed up with a smooth flat file with a safety edge.

Coming to the installing of the gland packings : first, insert gland rubber to gland nut, and then lightly smear gland cork with grease, and place on top of gland rubber. Next place taper spacer into gland boss

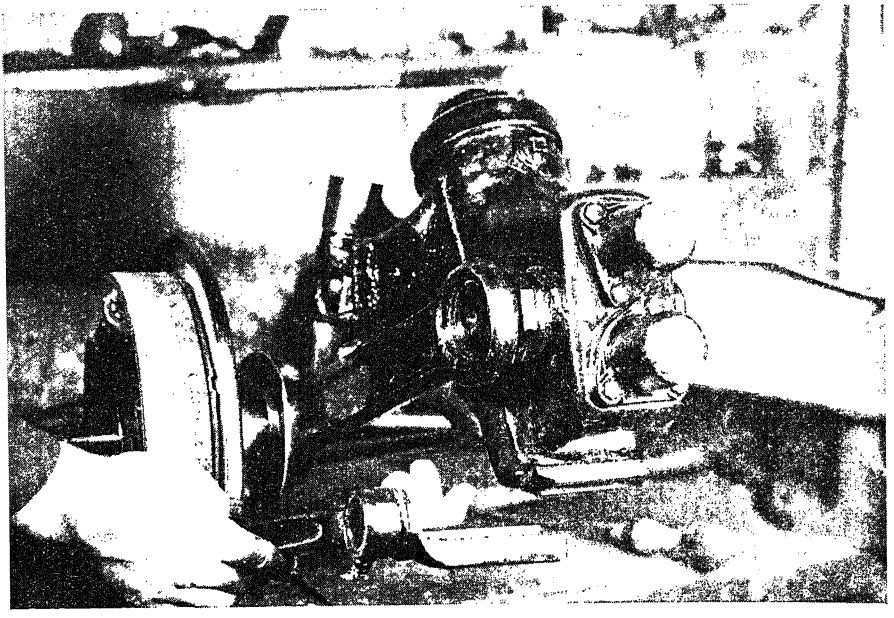


Fig. 13.—FITTING BRAKE SHOES AND LININGS TO KNEE-ACTION UNIT

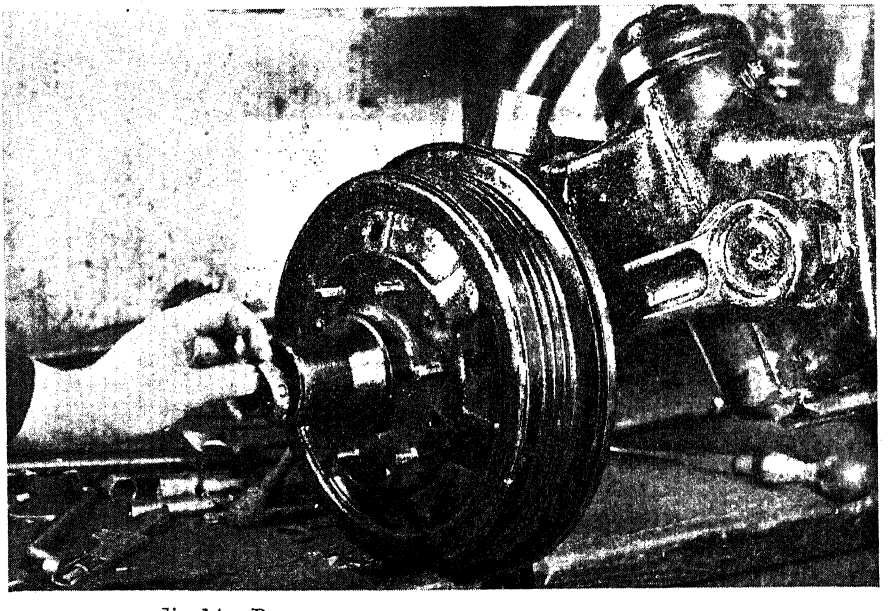


Fig. 14.—PUTTING IN BALL RACE AFTER FIXING BRAKE DRUM

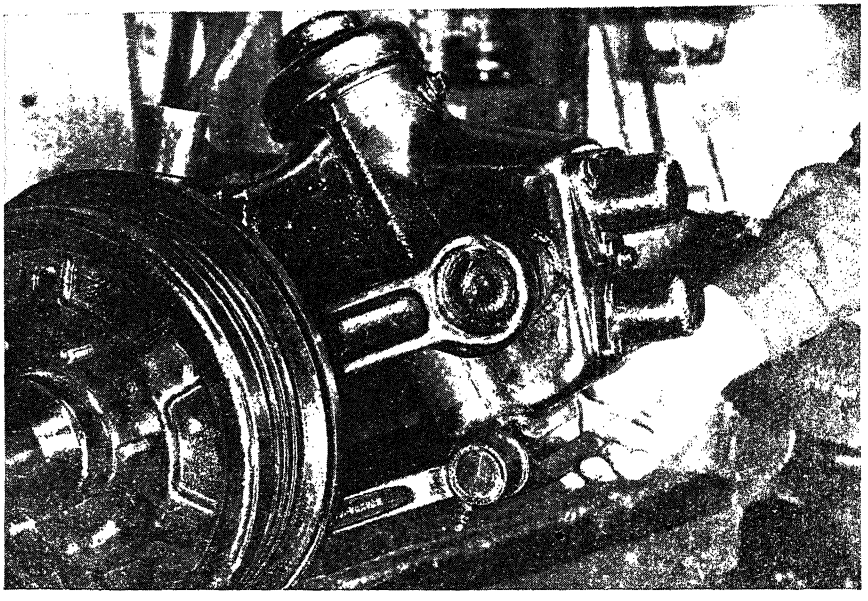


Fig. 15.—FIXING RADIUS ARM TO KNEE-ACTION UNIT

on knee-action body and screw on gland nut three to four threads. The next operation is to enter the wheel support spindle arm through the gland nut into the body, and by working arm up and down with some pressure, it will be found that the gland spigot on the arm will have entered nut and packings. Next unscrew arm and nut at the same time and withdraw wheel support spindle arm, and it will be found that the rubber and cork packings with the taper spacer will be in position.

Into the bearing on the gland side of body enter the needle-roller spacer, that is the $\frac{1}{4}$-in. broad spacer, and push through to the inside of bearing. Then into the bearing on the other side of body place another spacer and push through to inside. Now place main spring centre guide into knee-action body.

The needle rollers should now be placed around bearing on wheel support spindle arm ; these may be held in position by means of a small rubber band.

Now enter wheel support spindle arm ; care should be taken to line up correct spline so that cheese-headed locating screw can be entered first time. The gland nut should be taken up until wheel support spindle arm falls with its own weight. When gland nut is in position, grub-screw should then be tightened. The remaining needle rollers can now be inserted into the other bearing, and the special spacer placed in position. A new cork gasket should be put into the cap and a suitable sealing

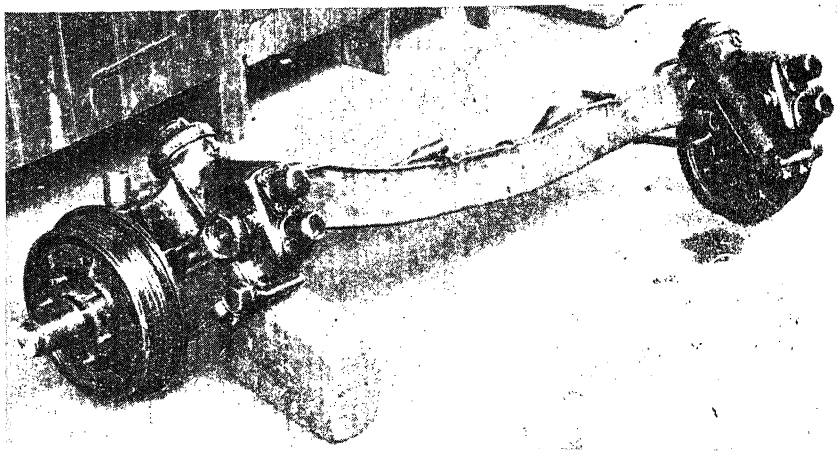


Fig. 16.—COMPLETE FRONT AXLE AND KNEE-ACTION SUSPENSION ON 1938 CHEVROLET

preparation smeared on the cork ; now lightly tap cap into position with a hammer.

The compression and rebound units may now be assembled with new gaskets, and should be tightened down equally.

Fill the knee-action unit with the correct fluid, as previously stated.

Remove the plug from the back of the front-wheel spindle and fill the reservoir with petroleum jelly.

Recheck knee-action heights to ensure the correct dimensions from the bottom of the king-pin boss to the bottom of the brake flange plate, as before mentioned.

It is advisable, after all knee-action overhauls, to check the front wheel track. This should be toe-in $\frac{1}{8}$ in. maximum. The track rod is adjustable by means of a right- and left-hand threaded tie-rod. After setting tie-rod, lock by tightening U-clamps on each end of tie-rod.

FRONT-WHEEL SUSPENSION OF 1939 MASTER DE LUXE CHEVROLET

Chassis coil springs are employed on these models and are mounted in seats, one seat attached to the lower control arms and the other in the frame front cross member.

The front and rear upper control arms are permanently attached to the shock-absorber shaft, to provide great strength and resistance to shock. This is controlled by double-acting shock absorbers of the end-to-end discharge type, which are rigidly bolted to the top of the frame front cross member.

The two upper arms of the shock absorber are electrically welded together.

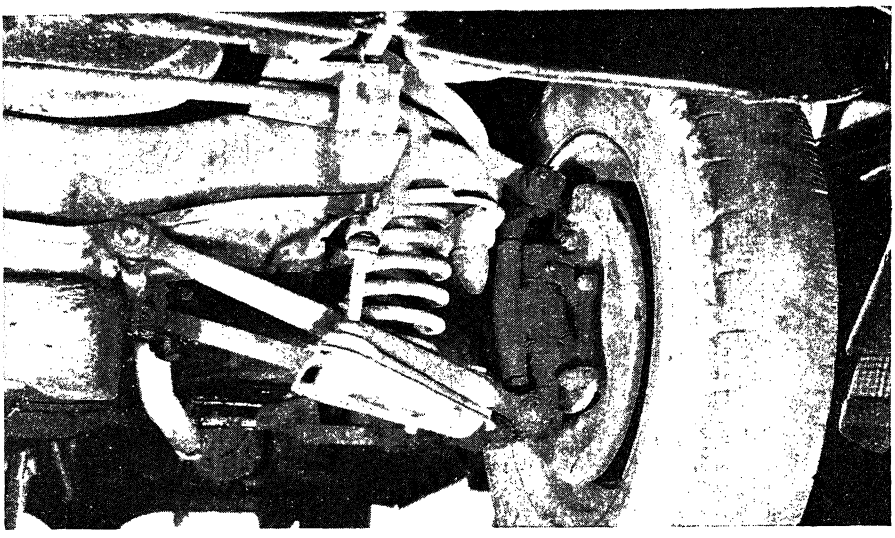


Fig. 17.—FRONT-WHEEL SUSPENSION OF 1939 MASTER DE LUXE CHEVROLET
Note greasing points.

The steering-knuckle support, which carries the steering knuckle and king pin, is pivoted at each end (upper and lower) to the corresponding control arms. At the lower end a steel threaded-type bushing is screwed into the steering-knuckle support. A threaded bolt which passes through both arms and the bushing completes the mounting.

Special seals protect the bearing from road dirt and water.

Two tie rods are used which connect directly to the Pitman arm—the offside tie rod is solid, but the nearside is adjustable to provide for toe-in adjustment.

Rubber bumpers for compression and rebound are mounted in the end of the frame front cross member. The lower bumper engages the lower spring seat bracket and the upper bumper engages the upper support arm at the point where the two arms are welded together.

To ensure the entire mechanism being as free as possible at all times, all nipples should be lubricated at least every 750–1,000 miles.

BRAKE MAINTENANCE—1939 CHEVROLET

To properly maintain the braking system, a thorough knowledge of the system is required. Particular care must be taken to see that all brake parts are thoroughly cleaned, and careful workmanship is very important in this connection. Absolute cleanliness is necessary to see that no foreign matter in the system will tend to clog the lines, ruin the rubber cups of the wheel and main cylinders, and thereby cause inefficient

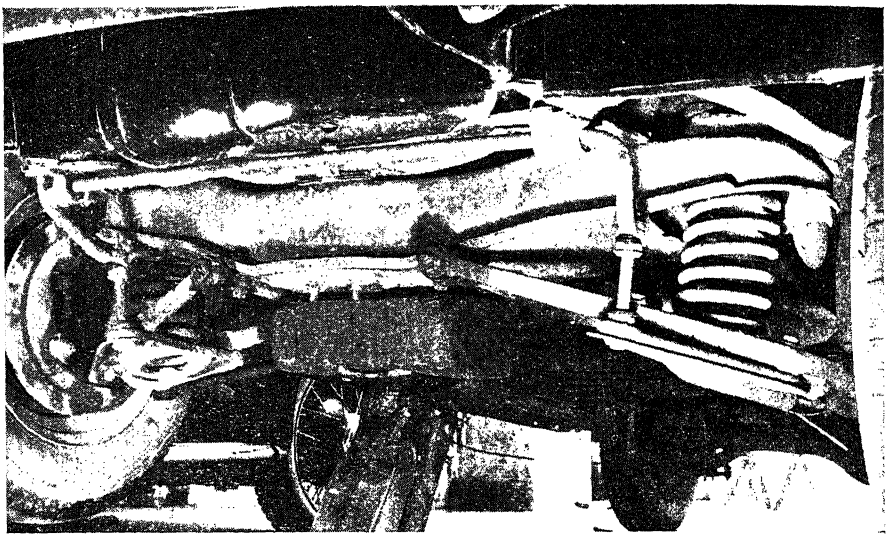


Fig. 18.—GENERAL VIEW OF FRONT-WHEEL SUSPENSION OF 1939 MASTER DE LUXE CHEVROLET

A simpler method to knee-action control will be noted.

operation or even failure of the system ; dirt or grease on a brake lining will cause a fade out on heavy application.

The hydraulic brake system must be bled whenever the pipe-line has been disconnected, or when a leak has allowed air to enter the system. The presence of a leak or spongy brake pedal usually indicates that air has been trapped in the system, and the entire system must be absolutely free from air at all times.

The longest pipe-line of the brake system should be bled first of all. Proper sequence for this operation is : left rear, left front, right rear, and, last of all, right front. During the bleeding operation the main cylinder must be kept at least half full of hydraulic brake fluid. The main cylinder automatically maintains the correct fluid level in the main cylinder during the bleeding process.

To Bleed the Hydraulic Brake System

Carefully clean all dirt from around the main-cylinder filler plug. Remove the plug, install adaptor and automatic filler. Open the automatic valve in the filler. Remove the bleeder-valve screw, attach bleeder drain pipe, keeping the end of the drain hose below the surface of the fluid in the jar. Unscrew the bleeder valve in the wheel cylinder half to three-quarter turn. Depress the foot pedal by hand, allowing it to return slowly. Continuing this pumping action forces the fluid through

the lines and out at the bleeder drain, carrying with it any air in the system. When bubbles cease to appear at the end of the bleeder drain hose and the stream is a solid fluid mass, tighten the bleeder valve and remove the drain hose. Replace and tighten the screw at the end of the bleeder valve.

After the bleeding operation has been completed, fill the main-cylinder reservoir approximately full and replace the filler plug.

Special attention must be called to the fact that fluid withdrawn in the bleeding operation should not be used again.

The correct fluid must always be used, which is Delco brake fluid.

In the event of improper fluid having entered the system it will be necessary to—

(1) Drain the entire system.

(2) Thoroughly and vigorously flush the system with clean methylated spirit.

(3) Replace all rubber parts of the system, and refill the system with the correct brake fluid.

Adjusting Brakes

These can be adjusted without the removal of the rear wheels. The adjusting hole for the front brake is located in the brake drum under the wheel flange, this will necessitate the removal of the front wheels to make the brake adjustments.

Floor-board clearance will very seldom need to be adjusted. The pedal stop, which is located in the brake master cylinder, is permanent. Before adjusting this stop, make quite sure that the pedal returns to the full released position freely, with no binding, and that the pedal return spring has not lost its tension.

To Adjust the Floor-board Clearance

Loosen the check nut on the eccentric bolt.

Turn the eccentric bolt in the proper direction to secure a $\frac{1}{2}$-in. floor-board clearance, and tighten the check nut.

Disconnect the emergency-brake pull rods from the brake cables. This can be done at the clevis just ahead of the emergency brake cable. It will be necessary for the emergency brake cable to be disconnected *before* the brake shoes are adjusted in the drums, to eliminate any possibility of a brake shoe dragging on the brake drum when adjusting the wheel cylinder, which avoids any possibility of false adjustment.

Jack up all the wheels so that they will rotate freely.

Insert a screwdriver in the adjusting hole in the brake flange plate and turn the adjusting nut four notches, to ensure the proper running clearance of the shoes and the drum.

Set the emergency brake lever in fully released position. The hand brake should be adjusted each time the hydraulic service brakes are adjusted.

Test car on road after each brake adjustment, to ensure satisfactory performance.

If upon dismantling the brakes it is found that the brake linings are worn, a satisfactory performance can be obtained by replacing only the forward shoes or brake linings when the back linings do not show excessive amount of wear. It is very often the case that the rear linings will outlast two sets of the forward linings. This is applicable to both front and rear brakes. Shoes or linings should always be changed in sets, namely, both forward shoes on the front wheels, or both forward and reverse on front wheels. The same applies to the rear wheels.

Correct brake linings are most important, otherwise faulty brake performance may ensue.

Do not use any abrasive on the brake linings ; drums must be heavily polished and thorough cleanliness must be observed.

Main-Cylinder Overhaul

In order to remove the brake main cylinder for overhaul it is necessary to carry out the following operations :

(1) Disconnect the main-cylinder pipe.
(2) Disconnect the wires from the stop-light switch.
(3) Remove the clevis pin from the piston push rod.
(4) Remove the main-cylinder retaining screws.

To Dismantle the Brake Main Cylinder

Remove the end plug and valve-seat washer and the valve-seat washer from the button on the end plug.

Remove the valve assembly and spring, the main-cylinder boot, the pedal-stop snap ring with a screwdriver, and also the pedal-stop assembly.

Dismantle the piston with the secondary cup and remove the primary cup.

After dismantling, all the parts should be thoroughly cleansed with *clean methylated spirit*.

Take special care to ensure that the compensating port in the main-cylinder housing and the bleeder holes are clean.

Before cleaning parts, thoroughly cleanse hands with soap and water.

Inspect the cylinder bore to ensure being smooth. Inspect the primary and secondary cups, valve, and valve seat for damage by grit or swelling. Replace parts when necessary.

Swelling of the rubber parts will be due to the use of improper brake fluid or the cleaning of the parts in petrol or paraffin.

Check piston fit in the cylinder bore. The clearance between the piston and the wall of the cylinder should be from ·001 to ·005 in.

Then check the clearance between the edge of the primary cup and the centre of the compensating port. In order to check this clearance, however, the main cylinder must be partially assembled, as follows :

(1) Install the pedal-stop assembly and lock in place with snap ring.

(2) Assemble the secondary cup on piston and install assembly in the housing. Place the primary cup in the housing, with the flat side of the cup against the piston.

(3) Push the piston and cup against the pedal stop and check the clearance between the edge of the primary cup and the centre of the compensating port. This clearance should be a minimum of ·035 in. This check is made easier by using a wire inserted through the filler hole of the housing and extending into the piston chamber. If the clearance is less than ·035 in., the primary cup must be replaced with a new one.

(4) After this clearance has been checked, the main cylinder must be again completely dismantled and reassembled according to the following directions :

To Reassemble the Brake Main Cylinder

After the hydraulic brake main cylinder has been overhauled for any purpose, great care must be exercised to reassemble the valves and seats correctly, as improper assembly of the seating rubber will result in distortion. There will be a consequent loss of brake-pedal travel, and the pedal must be depressed or pumped one or more times before actual car braking occurs.

In order to minimise the chances of distorting the check-valve seat, the following method of assembly is recommended.

(1) Insert a new check-valve seat washer in genuine hydraulic brake fluid, and assemble over the button on the end of the end plug. Assemble a new gasket over the end plug and screw the end plug, valve-seat washer, and gasket into the main cylinder housing. Tighten the nut securely.

(2) Inspect the valve-seat washer through the push-rod end of the housing, to make sure the washer is correctly seated.

(3) Dip the rubber cups and valves in genuine hydraulic brake fluid.

(4) Install the valve assembly from the push-rod end of the main assembly.

(5) Install the piston spring.

(6) Insert the primary cup in the housing, with the cupped side to the spring.

(7) Then assemble the secondary cup to the piston and assemble to the housing, so that the bleeder-hole end of the piston will be against the flat side of the primary cup.

(8) Install the pedal-stop assembly and lock in position with the snap ring.

(9) Install the rubber pedal-stop boot, ensure that the seal is tight on the housing, and that the vent hole in the boot is at the bottom. This seal must be tight to keep water and other foreign matter from entering the main cylinder through the pedal stop.

(10) After the main cylinder has been fitted to the chassis, it must be filled with genuine hydraulic brake fluid as previously stated, and all the pipe-lines at each wheel cylinder must be bled.

To Overhaul the Wheel Cylinder

In order to remove the hydraulic brake wheel cylinder, the car must be jacked up, the wheel and brake drums removed, the brake-system wheel cylinder lead pipe or hose disconnected at the wheel, and the brake-shoe return spring disconnected from the brake shoes. Two cap screws which hold the cylinder to the brake flange plate must be removed before the cylinder can be taken from the flange plate.

To Dismantle the Wheel Cylinder

Remove the cylinder adjusting covers, the pistons, rubber cups, and spring.

Wash all parts thoroughly in clean methylated spirit.

Inspect the cylinder bore to ensure that it is quite smooth. A scored or damaged cylinder must be replaced.

Check the rubber cups for damage or swelling due to incorrect brake fluid having been used. Replace the cups where or when necessary. Incorrect brake fluid will cause the cups to swell to a considerable extent.

Check the fit of the piston in the cylinder bore, using a narrow feeler gauge. The clearance should be ·003 in. and no greater than ·004 in.

To Assemble the Wheel Cylinder

Dip the pistons and rubber cups in the brake fluid.

Place the spring in the centre of the housing, the rubber cups at each end of the spring, the open face to the centre and the flat face of the cup flush with the piston.

Replace the adjusting covers with the adjusting screw in place.

Reassemble the wheel cylinder to the flange plate, connect the wheel-cylinder pipe or hose, and replace the brake-shoe return spring, brake drums, and the wheel.

After a wheel cylinder has been overhauled and replaced, it will be necessary for all hydraulic-brake lines to be bled.

In conclusion, particular care must be taken to ensure that the methylated spirit which has been used for cleaning out a system containing some mineral oil should never be used again.

SPECIAL POINTS TO BE WATCHED WHEN REPAIRING GUY COMMERCIAL VEHICLES

THE TRANSMISSION, AXLES, AND STEERING GEAR

By R. A. BISHOP

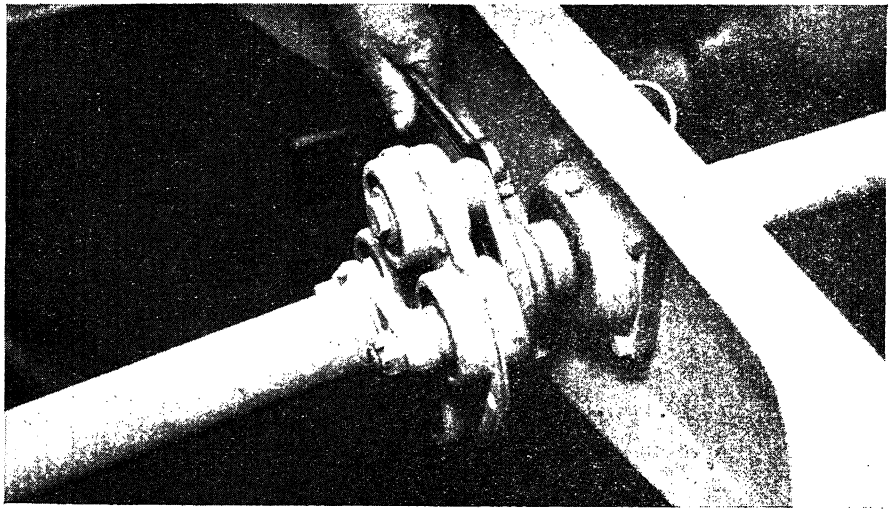


Fig. 1.—UNCOUPLING TRANSMISSION
Note washer between nut and rubber trunnions.

Transmission

THE transmission includes Layrub all-rubber universal joints, which require no lubrication whatever, as there are no moving parts.

For dismantling purposes it is necessary to remove the connecting bolts and compress the rubber trunnion block to the depth of the spigot bearing, which is approximately $\frac{1}{8}$-in., when the shaft can readily be removed.

Care should be taken on reassembly to see that the washers are fitted

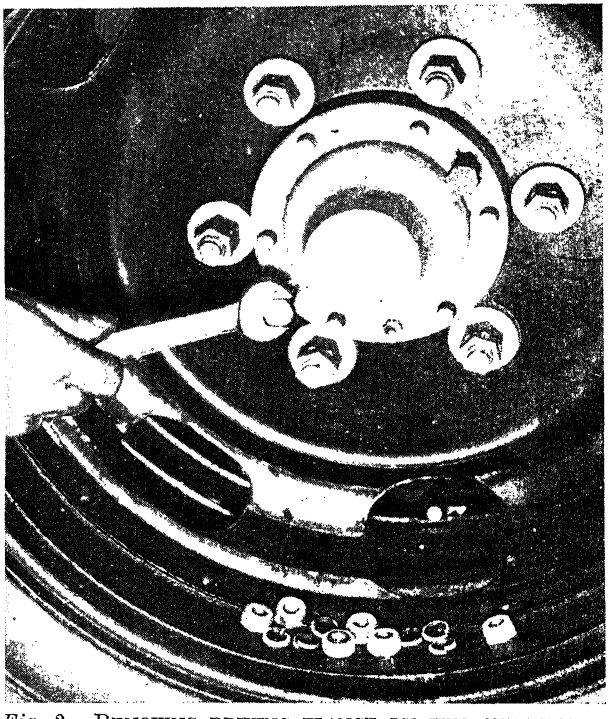


Fig. 2.—REMOVING DRIVING FLANGE BY TWO SET-SCREWS

under the shank or head of the bolt, and on no account should the hexagon-head bolts come into contact with the rubber trunnion block.

The slotted nuts should be tightened up to their full limit. The sleeve bolts are made from 3 per cent. nickel heat-treated steel, and care should be exercised to see they are tightened fully.

The intermediate bearing in the propeller-shaft line is of the radial type, and this should be periodically lubricated by the nipple provided.

Where the universal joints are of the all-metal type, lubrication is necessary at the sliding end of the shaft, by means of the nipple on the yoke shaft. These are lubricated for the first 5,000 miles, but the splines require a good grade of semi-fluid lubricant every 2,500 miles.

To lubricate the joint proper, remove the filler plug in the spider and inject a good grade of semi-fluid lubricant. The pressure-gun and fitting should be cleaned to avoid possibility of injurious foreign substances entering the joint.

When the joints are subject to heavy duty, it is well to remove the bearings twice a year, or every 30,000 to 40,000 miles, for inspection, cleaning, and repacking. It is a simple matter to disassemble the joints. Take out the eight bearing-cap screws and remove the bearings and spider. It is not necessary to take out the propeller-shaft assembly from the chassis, as each joint may be dismantled without removing the propeller shaft from the front slip joint.

After dismantling the rear joint, clean each bearing thoroughly and repack with a high-grade semi-fluid lubricant. Then reassemble the rear joint Now dismantle, clean, and lubricate the front joint in the same manner without removing the slip yoke from the propeller-shaft splined stub.

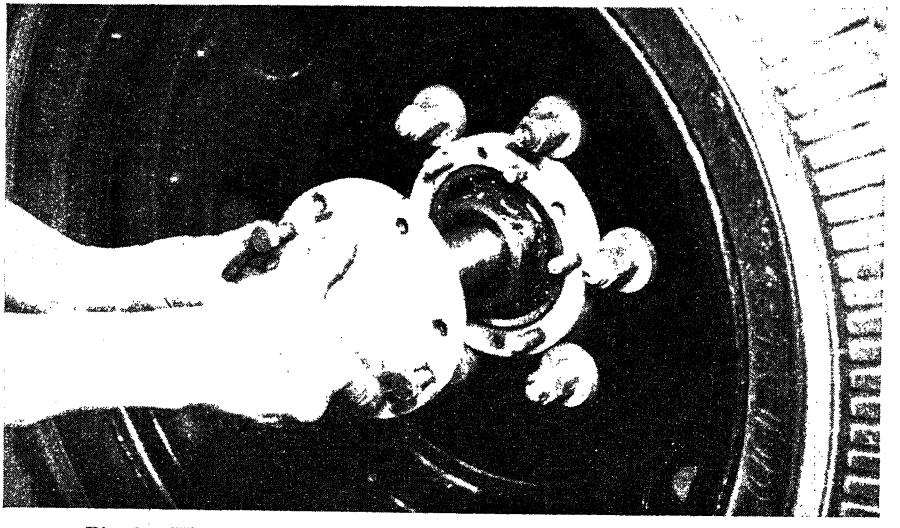


Fig. 3.—WITHDRAWING DRIVING FLANGE COMPLETE WITH HALF-SHAFT

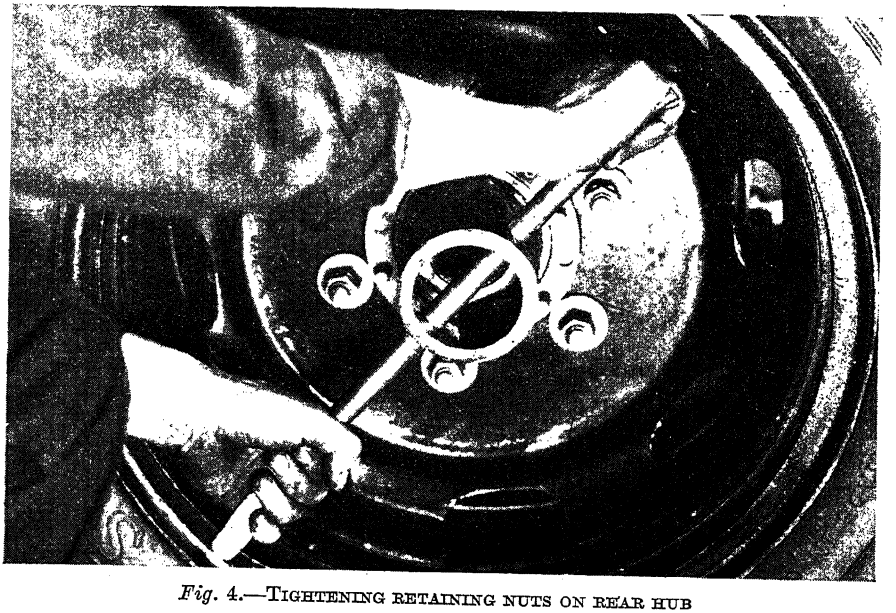


Fig. 4.—TIGHTENING RETAINING NUTS ON REAR HUB

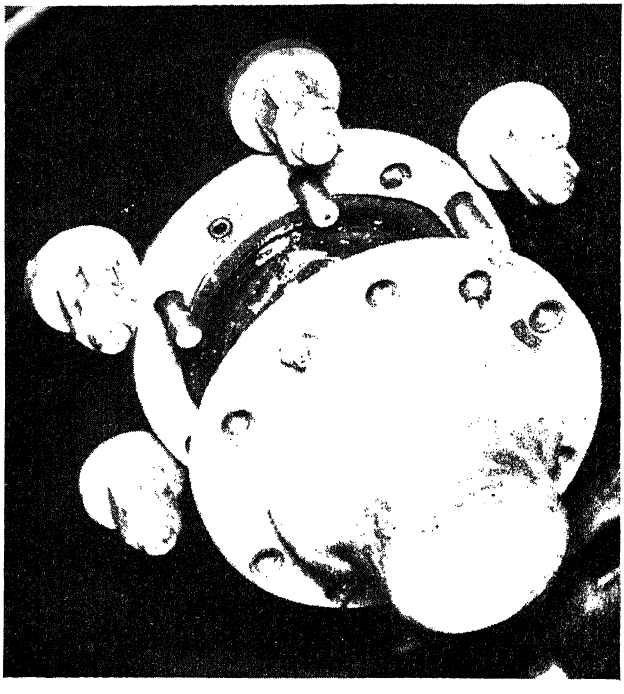


Fig. 5.—REPLACING DRIVING FLANGE

Showing position of cork washer when replacing driving nge. The grease hole should be in line with the grease nipple.

Reassembling the Transmission

The inexpensive cork seals should be replaced by new ones, when reassembling. It may be necessary, also, to replace the bearing-cap screw lockplates.

When the joints have been reassembled, make sure that the lockplates are turned up against the heads of the cap screws, so as to keep these in place.

To Remove Rear Hubs

First remove the road wheels, then driving-flange bolts, and withdraw flange complete with axle shaft. The driving flange may be eased off the spigot by inserting two setscrews in the tapped holes provided. Then remove the two rear-hub retaining nuts and lock-washer, when the hub can be withdrawn complete. When replacing the rear hub it should be noted that the two retaining nuts should be tightened up securely, as the bearings are of the ball-and-roller type and do not require endwise adjustment. Another important point is that the cork washer between the hub and the driving flange should be replaced so that the hole in this coincides with the hole for the grease nipple in the driving flange.

To remove Rear Drum

First remove the road wheels, then the six countersunk setscrews which secure the drum to the hub. The drum can then be removed, leaving the hub in position. When replacing the drum take particular care that it is mounted in exactly the same position as before removed, as if it is out of

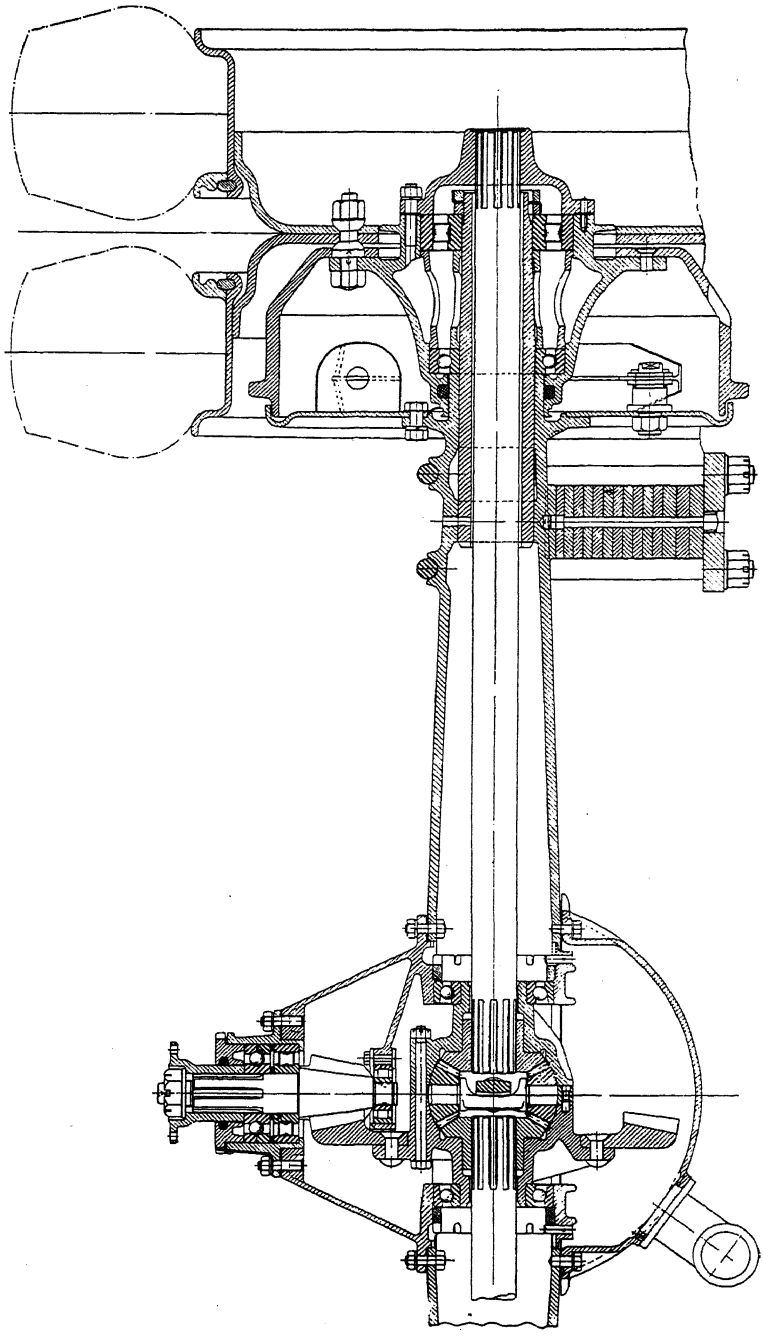


Fig. 6.—ARRANGEMENT OF REAR AXLE ("OTTER")

truth when refitted the operation of the rear brakes will be seriously affected.

Dismantling Rear Axle

With the axle shafts withdrawn and the propeller shaft disconnected, release the nuts holding the front cover of the rear axle in place, when the cover, complete with differential gear, may be lifted out.

After removal of the bevel gear and differential unit from the casing, it may be dismantled by removing the oil-retaining ring and locating bar which prevents the nut at the forward end of the casing from rotating. When that nut is unscrewed, the bevel pinion with its shaft and ball races will pull out. To dismantle the differential gear remove the two bearing caps to free the crown wheel and differential case. When the bolts holding the differential casing to the crown wheel are removed, the former will come away in halves, to expose the differential gear. Adjustment is by means of locking nuts at each side of the differential casing and at the end.

Brakes

These are of the Lockheed or Bendix type. These types are considered in Vol. I, and it is not necessary to describe them here or to refer to maintenance.

Front Axle

The front axle is an " I "-section steel forging, oval at ends to take braking torque. The hubs are mounted on taper roller bearings. Both swivel axles are fitted with hardened-steel bearings in upper and lower jaw, each lubricated by means of an accessible grease-nipple. The pivot pins are of hardened steel, each cut with a slot to take a taper pin, ensuring a firm fit in the axle boss. Each pivot pin is fitted with a taper roller thrust bearing between the bottom of the axle boss and the lower jaw of the swivel axle.

Front Hubs

To remove hubs jack up axle and unpin and remove the castellated nut, lock-washer, spacing washer (drilled with eight holes), collar, and shim. The hub and brake drum can then be drawn off, complete with the outer bearing. If the oil retainer and the dust cover behind the inner race are removed, care should be taken when refitting that the small hole at the bottom of these mates up with dowel in the stub axle. The correct alignment is when the measurement between the rims is $\frac{1}{8}$ in. less at the front than at the rear of the wheels, measuring at the line of the hubs. To adjust for track, take out one of the ball pins from the track-rod arm, slacken off clamping nut. The track rod can then be unscrewed or screwed up as required, but do not forget to tighten the clamp screws after the steering is properly set.

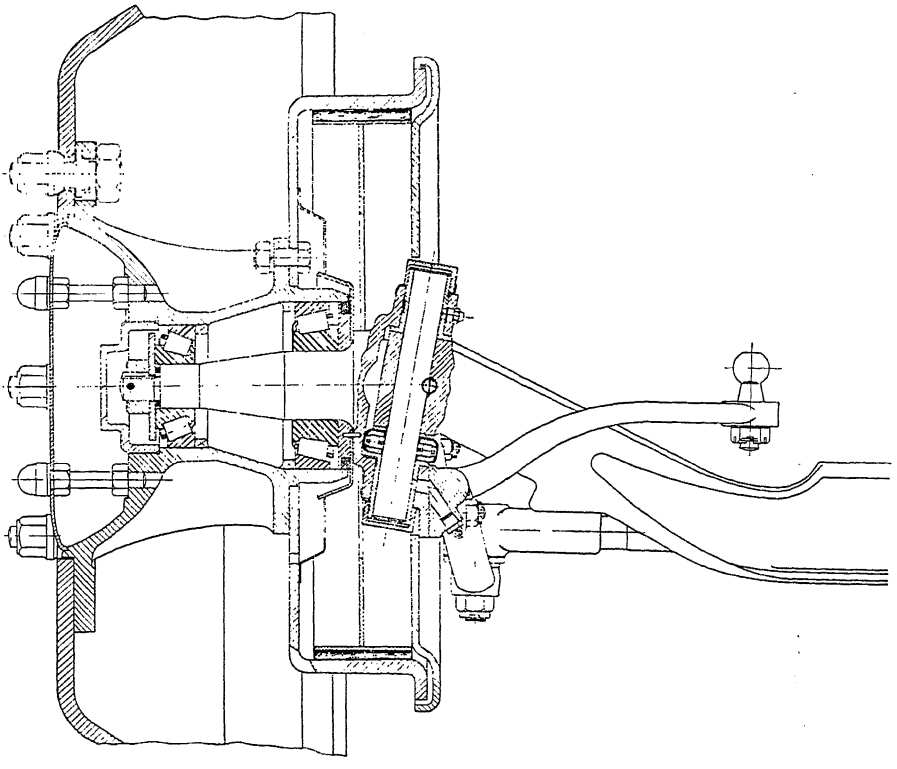


Fig. 7.—SECTION OF FRONT HUB AND SWIVEL AXLE

To dismantle Stub-axle Assembly

Remove front-brake assembly and backing plate. Remove taper pin in axle boss. Unscrew brass hexagonal nuts top and bottom, together with locking washers. Pivot pin can then be removed top or bottom. It will be noted that the slot which locates the king-pin is not centrally placed when refitting, therefore care must be taken to see that this slot corresponds with a similar slot in the axle beam. It should be noted that the bottom bush has a flat on the edge of the flange. Before refixing the top and bottom brass hexagonal nuts see that the locking washers are fitted.

Play in Stub Axle

As the pivot pins and bushes are of hardened steel it is unlikely that wear will develop in these. Should end play eventually occur in the stub-axle assembly, this can be taken up by inserting another packing washer between the thrust bearing and the lower portion of the axle boss.

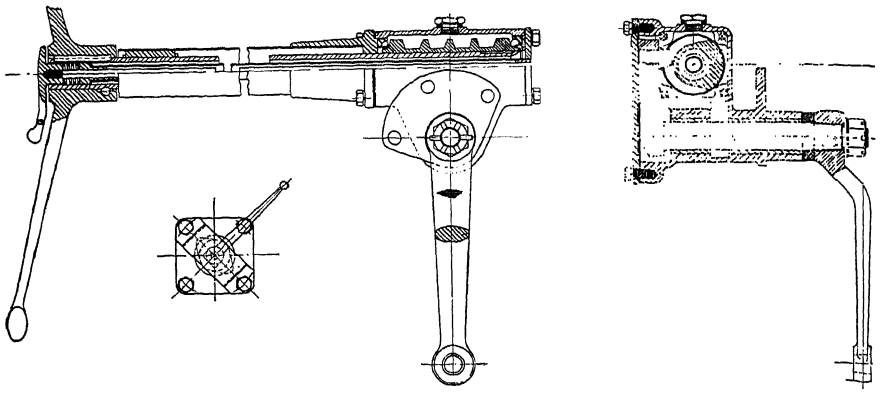


Fig. 8.—SECTION OF STEERING GEAR

The correct adjustment is such that the bearing is very slightly " nipped " between the stub-axle bosses when the vehicle is jacked up.

When replacing the taper thrust bearing on the lower portion of the stub axle, take care that this is fitted correctly, i.e. with the portion marked " Top " nearest to the axle boss.

Steering Gear

The steering gear used is of the cam-and-roller type. As will be seen from the illustration above, this gear is a self-contained unit of extreme simplicity. The whole of the mechanism is contained in an oil-tight casing, and replenishment of the oil at intervals of about six months is the only attention that is likely to be necessary on the part of the owner.

Lubrication

On no account must grease be used. Use heavy gear oil or " Kamoil," a lubricant specially manufactured for this steering gear. The box may be kept as full of lubricant as possible. The internal mechanism is automatically lubricated, but a spot of oil should be injected with an oilcan from time to time into the recess surrounding the stationary tube of the central control at the top of the steering wheel, and also to the bearing at the top of the outer column.

Adjustment

The cam and main shaft are mounted on ball bearings which take the thrust from the rocker shaft, and shims are fitted under each end cover so that the cam is mounted centrally in the box. It should never be necessary to alter the adjustment, which is carefully set before the vehicle leaves the works, but if the gear is dismantled for cleaning or inspection a careful note of the number of shims at each end should be made. On

reassembly the shaft should spin with the fingers, but there must be no play whatever.

Rocker Shaft

The motion of the steering wheel is transmitted to the road wheels through the cam and roller fitted into the lever inside the steering box, and in time a small amount of wear may possibly become apparent. This will be shown by loose motion between the steering wheel and the drop arm. The whole of this can be removed and the gear restored to its original perfection by removing one or more of the shims from underneath the cover plate on the side of the steering box. If too many shims are removed the gear wheel will become stiff, and this must not be permitted.

All adjustments to the steering gear should be carried out with the drag link disconnected.

Removal of Drop Arm

The drop arm is attached to the rocker shaft by means of a splined taper, and secured by a slotted nut. It may be difficult to remove the drop arm from the shaft unless a drawer is used on the lugs provided for this purpose. If it is ever necessary to remove the drop arm with a hammer, the side cover plate must first be moved, and the shaft should be driven through the drop arm so that the reaction from the blow is taken on the main casing instead of on the hardened-steel cam and roller.

When replacing the drop arm take care to refit it to the correct spline to give an equal lock. The most simple method of finding the correct position is to attach the drop arm to the drag link by the ball pin, place the road wheels in a " straight ahead " position, and turn the steering wheel as far as it will go on the left lock, then bring it back three-sevenths of its full motion and mount the drop arm on the spindle in this position. Care must be taken to ensure that the slotted nut is tightened right home, and the nut securely split-pinned. The front axle should then be jacked up to see that there is full lock on both sides, and that the stub axles are properly up against the stops on the front-axle bosses.

The only thing that can cause the steering to become stiff in use (apart from the front axle and its connections) is lack of lubricant between the revolving shaft and the steering gear and the stationary tube of the central control, or lack of lubricant in the box itself.

When properly adjusted the steering should be finger light, free from backlash, no road shock should be felt on the wheel, and the vehicle should straighten up well after cornering.

Tyre Pressures

The correct tyre pressures for the " Vixen " and " Otter " 3- and 4-tonners are as follows :

Tyre Size	*Pressure (lb. per square inch)*
32 × 6·00 Low pressure . . .	. Front—45. Rear twin—50.
32 × 6·00 High pressure, truck type .	. Front—80. Rear twin—80.
32 × 6·00 Heavy-duty . . .	. Front—80. Rear, single, or twin—90.

Body

Body squeaks are generally rather difficult to locate, but should a squeak develop it should be traced to its source and rectified, as it means that strain and consequent wear are being imposed at this point.

Occasionally, the tightness of the body holding-down bolts should be checked with a spanner. This will prevent any possibility of the body bolts shearing or a dull chattering occurring when passing over a rough road, due to the body moving on the chassis.

SERVICING COMMER VEHICLES

REAR AND FRONT AXLE, PROPELLER SHAFT, STEERING AND BRAKES

By B. M. SMITH

IN dealing with the repair of Commer vehicles it is convenient to separate the entire range into three general types, i.e. 8 cwt.; 15 cwt. and 20/25 cwt. (type N.1); and N 2/3 and 5 tons.

8-CWT. VAN

Rear Axle and Propeller Shaft

The rear-axle unit is a semi-floating type with spiral bevel drive of conventional pattern, and should present no special difficulty.

The following remarks apply to all vehicles up to chassis number 7100499, but a different procedure is necessary for the axle now in use fitted to chassis 7100500 and onwards.

The complete unit can readily be detached from the rear axle casing after removal of the axle shafts, and all roller bearings are adjustable.

The hub is integral with the axle shaft, and is removable after the brake drum has been detached to allow removal of the three nuts securing the hub-bearing retainer plate.

When replacing, the retainer plate must be refitted so that the clearance for the two nuts in the backing plate is opposite these two nuts.

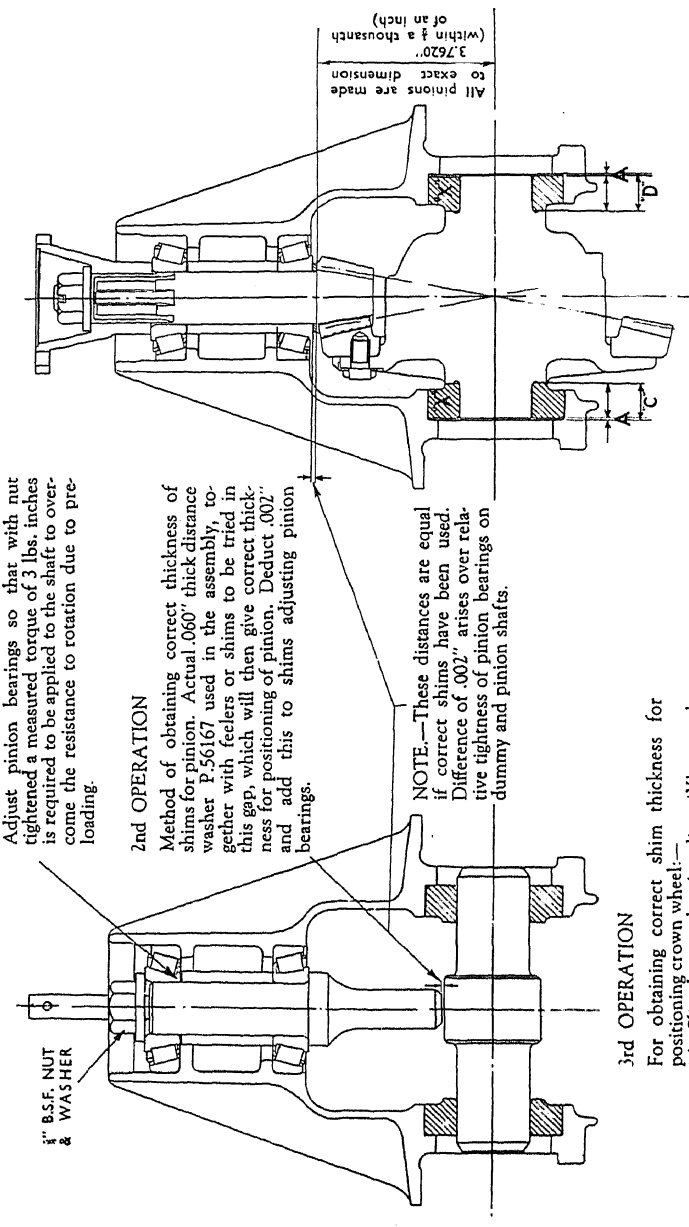
The complete pinion assembly can be withdrawn by undoing the nuts holding the casing—taking care to replace the same shims, unless the axle mesh has been adjusted.

The assembly can be refitted only with the two drain holes at the bottom.

Dismantling is effected by removing the drive flange, after which the pinion shaft and rear bearing can be pressed out, preferably leaving the oil seal and front bearing in place.

Adjusting shims are fitted between the rear race and distance-piece to allow wear in the bearings to be taken up.

To dismantle the differential remove bearing caps, first marking the adjuster to ensure reassembly with the original adjustment, and lift the unit out complete, taking care also to mark the outer bearing rings so that they are correctly replaced.



1st OPERATION

Adjust pinion bearings so that with nut tightened a measured torque of 3 lbs. inches is required to be applied to the shaft to overcome the resistance to rotation due to preloading.

2nd OPERATION

Method of obtaining correct thickness of shims for pinion. Actual .060" thick distance washer P.56167 used in the assembly, together with feelers or shims to be tried in this gap, which will then give correct thickness for positioning of pinion. Deduct .002" and add this to shims adjusting pinion bearings.

NOTE.—These distances are equal if correct shims have been used. Difference of .002" arises over relative tightness of pinion bearings on dummy and pinion shafts.

3rd OPERATION

For obtaining correct shim thickness for positioning crown wheel:—

(a) Slip dummy bearing discs 'X' on ends of differential carrier, insert feelers at point 'A' with correct back lash between gears.

(b) Obtain distances 'C' & 'D' by adding together thickness of feelers used plus

(c) Measure exact overall height of actual bearings to be used and subtract from dimensions 'C' & 'D' this will give actual thickness of shims required. Add .001" to each side.

Removal of the bolts passing through crown wheel and differential box will allow the latter to be split for access to the differential pinions. The two differential halves are marked to ensure correct reassembly.

Differential Adjustment

Longitudinal adjustment of the bevel pinion is by means of shims between the pinion nose-piece and differential casing.

These shims can be fitted only one way, with the elongated hole on the bottom right-hand or 5-o'clock stud.

So far as the present axle unit is concerned, although all bearings are still adjustable by means of shims, no screwed adjusters are incorporated. Dummy shafts are used to determine the shims required. Should it be necessary to alter the adjustment the following sequence must be adopted :

Remove bearings, shims, and distance-piece from pinion shaft and build up dummy shaft with the pinion housing, after removing the oil seal, finally fitting coupling nut and washer and tightening fully.

Check bearings for adjustment, adding or removing shims as required from between distance-piece and bearing.

When correctly adjusted, the bearings should be pre-loaded. This amount is measured by testing the torque required to turn the shaft, which should be 3 lb. in.—equal to a load of ½ lb. on a 6-in. lever.

The lever arm can be inserted in the tommy-bar hole in the dummy shaft and load applied by a spring balance.

Having established the correct pre-load, fit the centre jig into the casing, using the two dummy bearings.

The gap between the end of the dummy shaft and the centre jig should be measured with feeler gauges *and* the original spacer washer.

The measurement taken by the feeler gauges is the thickness of shims to be built on the pinion shaft when reassembling.

In practice, in fitting the bearing on the shaft it alters its length by ·002 in.

This should be *subtracted* from the thickness of shims required to fill the gap, and *added* to the shims at the end of the distance-piece between the bearings.

Therefore, to build up the pinion shaft, first fit the thick washer, chamfer downwards, then the correct number of shims as determined. Next press on the inner member of the rear bearing, following with the shims with ·002 in. added—and then the distance-piece.

Now refit oil seal to casing, coating the outer cage with quick-drying compound, finally rebuilding the pinion into the casing.

This completes the pinion assembly.

Having reassembled the differential box remove the two bearings, and in their place fit the dummy bearings without shims.

Assemble in the housing, still using the dummy bearings, and fit the caps.

With a suitable length of tube, drive the dummy bearings inwards until the correct backlash between the gears can be obtained.

Measure with feeler gauges the gap *A* shown on Fig. 1.

Obtain distance *C* and *D* by adding ·8 in. (the thickness of the dummies), to the size of gap *A*.

By measuring the height of the actual bearings and deducting from *C* and *D*, the thickness of shims required can be obtained.

It is recommended that an additional ·001 in. be added to each side.

There are two methods of measuring the height of the bearings, in each case using the dummy as a comparison.

The first is by use of a surface-plate and a dial gauge—setting this to give a zero reading by use of the dummy bearing. The reading is then taken on the actual bearing, the amount shown on the gauge being the difference.

Alternatively, a straight-edge can be laid across the bearing and the dummy, the difference being measured by feelers.

Now remove differential box from casing, withdraw dummy bearings, and fit the necessary shims in accordance with the dimension obtained in the manner just detailed.

Press on the bearings, replace the complete assembly, and tighten up the bearing caps.

Oil Seals

A spring-loaded leather oil-seal assembly is fitted to the pinion nose-piece, and if at any time it is renewed the outer edge of the seal should be coated with jointing compound before assembly, to prevent leakage between the seal and case. The sharp edge of the leather must face the rear axle. A similar seal is fitted in the rear hub to prevent oil passing up the shaft from the differential.

In addition, a felt is fitted in a housing on the catcher spot welded to the bearing retainer plate.

Should leaks occur at the rear hub, make sure that this is not due to over-lubrication of the hub bearings.

A catcher is spun on the rear of the hub, and it is important that the drain holes drilled in the hub, brake drum, and wheel be kept clean, to prevent surplus lubricant finding its way on to the brake shoes.

Propeller Shaft

This is of the Hardy Spicer needle-roller type, and as all bearings are packed with grease when new, it is necessary only to grease the splined portion.

The shaft must be fitted with the sliding part to the front of the car.

Further, the front and rear joint lugs must be in line and not at 90° to each other.

Brakes

These are of Bendix duo-servo type, and full details of maintenance and adjustment are given in a special section in Vol. I.

It is recommended that there be a slight lead on the front brakes, say 60 per cent. on the front to 40 per cent. on the rear.

The necessity for using only genuine replacement shoes is again stressed, as it is not possible to obtain satisfactory braking if new liners only are fitted. Periodic lubrication of the cables is essential, using Bendix graphite grease, and all moving parts should also be inspected and greased to ensure freedom of movement.

Important

Under no circumstances must an endeavour be made to adjust the brakes by altering the lengths of the cables.

Front Axle

The swivel pins are carried in the axle beam and secured by taper cotters.

To dismantle the stubs, the pins must be driven out after removal of the cotters, and to facilitate this they are drilled and tapped in the top to take a special extractor.

If this is not available, the pin may be driven downwards with a suitable drift.

Should it be necessary to fit new bushes, these should be reamered to suit the pin after they are pressed into position.

The track should be maintained at all times with $\frac{1}{8}$-in. toe-in.

The track-rod ball joints are of the self-adjusting type. Should any play exist this may be due to the self-adjusting mechanism becoming jammed or rusted up.

Grease should therefore be forced in, and the joint well worked to release it.

Steering

The steering gear is a Burman-Douglas unit, of the steel worm and bronze nut type, the nut in turn operating the rocker shaft. Full details as to maintenance and adjustment are given in a separate section in Vol. I.

To remove the steering unit, this should be withdrawn downwards, with the car over a pit, leaving the detached steering wheel and controls in the van.

It is recommended that a long piece of string be tied to the wires in the inner column before removal.

This will be drawn up the column and should then be detached and left in place to facilitate reassembly.

It is also advisable to mark the steering wheel, to ensure that it is replaced in correct relationship with the inner column.

15 CWT. AND 20/25 CWT.

A Hardy Spicer needle-roller type propeller shaft with 1300-size universal joints is fitted, and no running attention beyond lubrication of the slip spline shaft is required. No provision is made for greasing the needle bearings, but it is recommended that these be taken down and repacked with grease periodically, say when dock overhaul is taking place, or every 2,000–3,000 miles.

To remove Propeller Shaft

Remove all bolts from the flanges holding shaft to gearbox and rear axle, telescope shaft on splines, and it will then have shortened sufficiently to permit being lifted away.

When entering splines to replace slip joint on shaft, assemble so that sleeve-yoke lugs lie in the same plane as stub ball-yoke lugs. Arrows are stamped on sleeve and shaft for this purpose, and need only be placed in line. Special steel bolts with lock-washers under both head and nut are fitted to the coupling flanges, and no others should be used.

Replacement of Needle-bearing Assemblies

This can be done if necessary without removing shaft from vehicle, but the work can be carried out much more easily on a bench ; in either case the procedure is the same. Take out the snap-rings holding an opposed pair of needle-bearing assemblies by means of pointed pliers, and with the yoke from which the rings have been removed supported, tap one of the bearings—using a suitable drift—until the one on the opposite journal lug is released and can be lifted away. Now, with a piece of wood or a soft-metal drift, tap on the exposed end of the journal and the other assembly will be forced out. This procedure is followed to extract all the bearings.

In reassembly pack bearings with high-speed grease only ; many failures can be traced to the use of unsuitable lubricant.

It is generally found advisable to renew the needle-roller assemblies in sets and at the same time fit new journals. Care should be exercised to see that the oil gaskets are undamaged by removal of the bearings ; if any doubt as to their efficiency exists, a new journal assembly should be fitted. The makers do not supply these gaskets separately to the journals, as a special process is necessary in assembling the two details.

REAR AXLE (15 CWT. AND 20/25 CWT.)

The rear axle is of the semi-floating type, spiral bevel pinion and crown wheel being fitted. The forward end is a casting in which the whole of the gear set is carried, and this can be removed after withdrawal of the driving shafts.

Taper roller bearings are fitted, and provision for adjustment is provided in all cases.

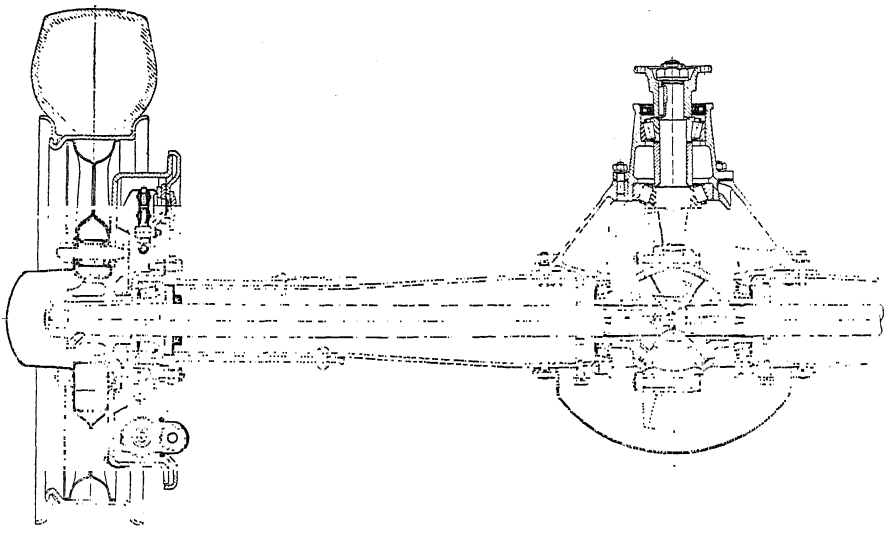


Fig. 2.—ARRANGEMENT OF REAR AXLE, TYPE 15 CWT.

Removal of Axle

This can be done either by taking off the nuts from the spring-holding U-bolts or by withdrawal of the spring shackle pins. The amount or nature of the work to be carried out will decide which method is adopted ; the procedure is quite straightforward and will present no difficulty whatever. Brake cables should, however, be detached at cross-shaft.

If removal of the banjo is undertaken, one point to watch is that the makers carried out a modification to spring location and, as only the latest type banjo is now supplied, some doubt may arise in fitting.

Briefly, the first type of spring location had the dowel bolt machined in two diameters, the larger diameter locating in the spring bracket and the smaller projecting through a hole drilled in the casing itself. Subsequently, to prevent drilling the casing, the smaller diameter was dispensed with, the dowel bolt being shortened by this amount.

Replacements of this later type of case will be received, and in fitting to a spring in which the old type of dowel bolt is employed it will be necessary to cut away the small diameter of the bolt. It is hardly necessary here to emphasise the importance of following up the spring holding-down bolts if these have been disturbed.

Adjustment of Wheel Bearings and Withdrawal of Axle Shafts

Take off road wheels and brake drums ; it will be noted after removal of the wheel that the drum is fastened by countersunk setscrews to the hub ; extract these and the latter can be lifted away. If it is desired only

to *adjust wheel bearings*, this can now be carried out without further dismantling by turning back the adjuster locating screw and screwing in adjuster until tight, slack back about eight notches, and lock. Adjustment of one bearing will be sufficient if there is only slight play, but if more than one complete turn of the adjuster is required, it should be divided equally between both sides.

There is no necessity to separate the hub and axle shaft, as they can both be removed as one unit by unscrewing the bearing adjuster as far as possible and withdrawing shaft with its bearing to the limit permitted, this operation then being repeated until the assembly is clear of axle.

A felt oil-retaining assembly will be found pressed into the axle casing at the hub end of tube and in case of excessive oil leakage may need renewing. It is advised that only high-speed grease be used for the hub bearings, and this only in reasonable quantity, for obvious reasons.

Should it be necessary to part hub and shaft use a withdraw claw, especially if this is being done with driving shaft still in axle. In case a new hub is being fitted to an old shaft, or vice versa, make sure that tapers are a perfect fit by grinding one in the other with very fine grinding-in paste. Do not use a file or emery-paper.

On later-type machines, it will be found that wheel studs are dowelled to the hub and it is advisable to carry out this modification on the earlier machines when opportunity occurs. Suitable studs and dowels can be obtained from the makers or, of course, the shoulder on the existing studs and the flange of the hub can be drilled, location being by means of $\frac{3}{16}$-in. steel wire.

Adjustment of Differential Bearings

This can be carried out with axle still assembled, access to the adjusters being obtained by removal of rear cover.

The bearing-cap nuts must be slackened a little and the adjuster locking screws taken out of bearing caps. Adjust until there is no perceptible slackness left by screwing in both adjusters an equal amount.

The correct backlash between the pinion and crown wheel will permit approximately $\frac{1}{32}$-in. movement on the propeller shaft driver coupling when the crown wheel is wedged.

Check that locking screws are replaced correctly and cap nuts tightened up.

Pinion-bearing Adjustment

This is a further operation which can be carried out without completely dismantling the axle.

First remove bolts holding propeller shaft and pull clear of axle. The pinion sleeve, complete with the bevel pinion, roller races, and propeller-shaft coupling, must now be taken from the differential housing. Shims will be found between these two members for adjusting the gears.

The shims must be returned exactly as originally fitted unless renewal of crown wheel and pinion is being undertaken. Instructions relating to this operation are given in the following section.

Remove driver coupling and key from pinion and the latter may then be tapped out of housing, shims in 25 or 40 S.W.G. for bearing adjustment being immediately between the front bearing and distance-piece. Shims may be removed until there is no perceptible end float ; do not, however, pre-load the bearings.

Crown Wheel and Bevel Pinion Replacement

As previously indicated, the whole of the gear set is carried in the differential casing which, after withdrawal of axle shafts, can be removed subsequent to the ring of nuts holding it to axle being taken off.

Apart from dismantling of bevel pinion, procedure for which is given above, no problem will be found in stripping the unit.

In order to reassemble, put differential, on which the new crown wheel has been fitted, into casing and by means of bearing adjusters centralise unit as nearly as possible. Tighten up bearing-cap nuts sufficiently to hold the assembly firmly, but do not split-pin.

Now assemble pinion in housing, adjusting the bearings as indicated above, and without any shims between the pinion housing and differential casing insert the former until the " lapping-in " marks on the pinion coincide with those on the crown wheel. Ascertain number of shims required between pinion housing and casing by offering them edgeways until exact thickness has been found. Shims are obtainable in thicknesses of ·005 in., ·016 in., and ·032 in. It is advisable to add one ·005 in. extra to compensate for nipping, and after putting these on studs the pinion assembly can be finally tightened on the differential casing.

Finally, the crown wheel must be adjusted sideways as indicated under " Adjustment of Differential Bearings," and the meshing tested by means of marking blue.

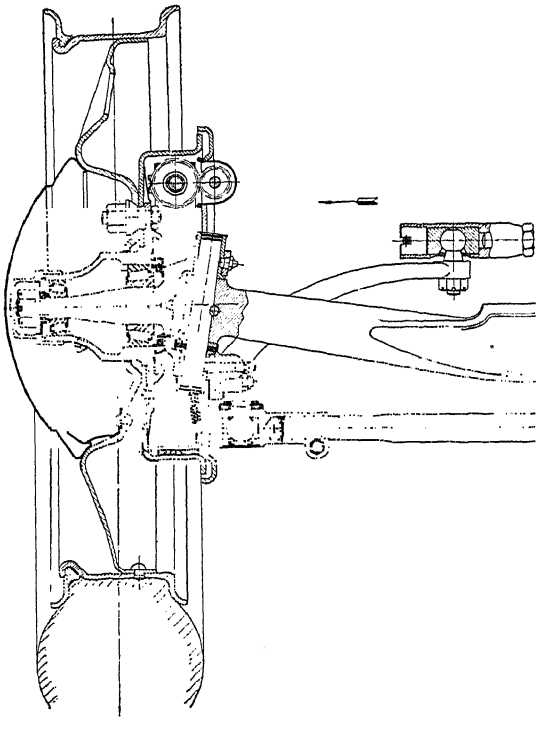
FRONT AXLE (15 CWT. AND 20/25 CWT.)

Front-axle beam is of I-section between spring pads changing to oval section at the ends. A Thompson track rod is employed, and the wheel bearings are of the taper-roller type.

Removal of Front Axle

On the N.1 forward-control model the axle is held to the springs by eight bolts, but the remaining types utilise U-clips. The nuts on bolts or clips must be removed and the side rod disconnected from the steering ball in either steering arm or drop arm. (If the split-pin is taken out of the side rod, the end plug can be screwed back and the ball will be released.)

Detach brake cables from cross-shaft and the unit can be rolled forward.



g. 3.—ARRANGEMENT OF FRONT AXLE (TYPE N1)

Dismantling

Dismantling is extremely simple and commences, of course, with removal of wheel and nave plate. On all the 15 cwt. and also the early N1's, the nave plate is held by the wheel nuts or, alternatively, setscrews fitting in the wheel nuts, but the later type N1 nave plate is fitted on springs riveted to the wheel: this type is easily sprung off by the insertion of a screwdriver.

Screw off hub cap (right-hand thread both near and offside) and remove stub axle end nut, bearing tab washer, distance-piece, and safety washer. Hub and brake drum can now be drawn off, and all hub parts will be available for inspection.

Before swivel pins can be removed it is necessary to take off brake backing plate—which is held to stub by six bolts—in order to give required clearance. It will be noted that the two bottom bolts also hold the steering arm, and releasing the arm here obviates the necessity of disconnecting the track rod.

It is now necessary to point out the effect of modifications affecting both swivel-pin bushes and the method of pin location.

The first type of pin employed was of hollow tube located by a taper pin ; the later of solid bar fixed by cotter and nut.

Dealing now with the bushes, it will be found that the first were closed by a cap nut screwed on and held in place by a lock-washer. The later have a sealing disc in the end of the bush in which a groove is cut to receive it. Location of the bottom bush throughout is by a flat cut on the side of the bush butting against the steering arm, and the cap nut held the top bush when the bush was fitted ; now, however, the top bush is positioned by a special-type greaser.

After removal of backing plate and steering arm it will be seen that there are alternative methods of extracting swivel pins. In the first case, turn down lips of cap-nut locking tabs, unscrew cap nuts, and drive out

taper or cotter pin. (It is pointed out that as the above modifications did not take place simultaneously such an alternative will apply.) The swivel pins can now be tapped out.

In the second case simply remove cotter pin and with a suitable drift on the sealing disc in the bush drive this and the swivel pin through until the disc at the opposite end is released. Now change the drift to the exposed end of the pin and drive same completely out, sending the remaining sealing disc before it.

Reassembling Front Axle

In reassembly the swivel pin *must* be a tight press fit in the axle, and if any doubt exists fit one of the oversizes which are obtainable : + ·005 in., + ·010 in., and + ·015 in. An oversize pin will, of course, necessitate an oversize bush, and these being of steel the makers have made provision to supply in the same oversizes.

The steel thrust washer on the swivel pin is dowelled to the axle bed, and this point should be watched, as also that there is clearance between the swivel pin and the interior diameter of the bronze thrust washer.

The hub oil guard and distance-piece are dowelled and an oil-return felt is fitted between them. When replacing, be sure that the felt is not trapped between the hub and oil guard.

Adjustment of wheel bearings is carried out by means of the nuts on the stub-axle ends, and there should be just appreciable shake in the bearings.

Wheel Alignment

Correct "toe-in" is $\frac{1}{8}$ in. measured at hub centre-line of wheel, and the same point on the centre of tyre tread should be used at both front and rear.

One of the track-rod sockets has a left-hand thread and the other a right-hand thread. It is necessary only to loosen the clamping bolts in the sockets and turn the intermediate either in or out as required.

Steering Gear (15 cwt. and 20/25 cwt.)

This is a Bishop cam and roller unit as used on many makes of vehicle, both car and commercial, as described in Vol. I. It is only necessary here to indicate that the normal-control model is fitted with the B size while the forward-control utilises the H.

The method of removal of the unit is perfectly obvious, but it will be found that while on the normal control the horn and dipper switch wires can be disconnected at the junction box fixed near the steering gear on the frame, these must be disconnected at the horn and headlamp on the forward control.

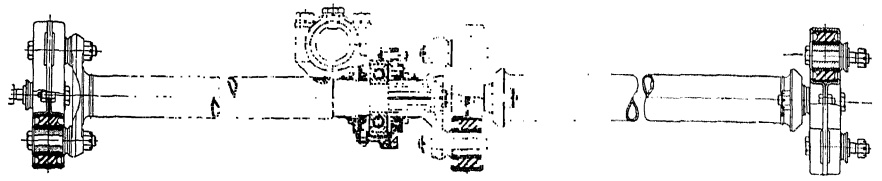


Fig. 4.—PROPELLOR SHAFT WITH LEYRUB COUPLINGS ON N5 AND LN5 MODELS

Brakes (15 cwt. and 20/25 cwt.)

Bendix Duo-Servo brakes are fitted to all four wheels, and all are operated by either foot pedal or hand lever. By means of slotted links interaction between the two systems is prevented.

Failure of any one part of the system will always leave at least two wheels with full braking efficiency.

The brakes themselves are dealt with in Vol. I, but it is stressed that no adjustment is possible by altering the operating length of cables or rods—the brake shoes must be adjusted in the drums.

Should it ever become necessary to detach cables from cross-shaft—as in removal of either front or rear axle—expand the shoes fully in drums on all four wheels and pull on both rods and cables to remove any slack before recoupling. If it is necessary, adjust foot-brake rod until yoke pins can just be inserted, and it will be found that there is just sufficient slack in cables to permit the flexible adjusters to give correct shoe to drum clearance.

N2, N3, N4, AND LN5 MODELS

Transmission

On the 2- and 3-ton models the propeller shaft is of the Hardy Spicer needle-roller type, but on the N5 and LN5, "Layrub" joints are used.

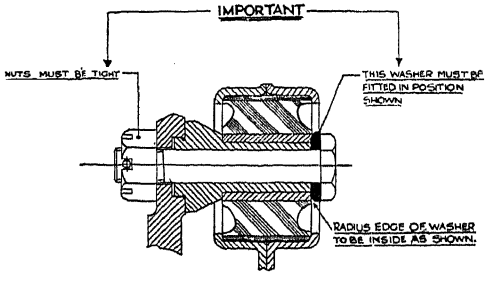


Fig. 5.—WHEN FITTING NEW LEYRUB COUPLINGS

Care must be taken to fit the washer with the radiused edge inside and nuts must be drawn up dead tight.

These latter call for no lubrication, but the bolts must be kept tight, and should be subject to periodic inspection, and if necessary tightened with a spanner having extended leverage.

The bolts are of high-tensile steel and will withstand considerable stress.

As far as the Hardy Spicer type are concerned, full details are given in a separate section.

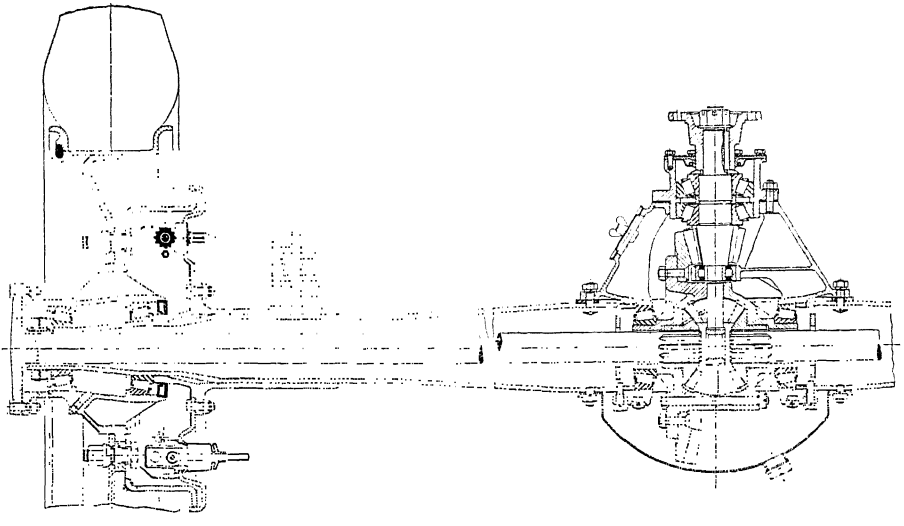


Fig. 6.—ARRANGEMENT OF REAR AXLE-TYPE N2

Rear Axle

The general type of differential unit is similar in all models, although that for the N5 and LN5 is naturally heavier and also incorporates an overload-thrust button.

Axle shafts are fully floating, and after these and also the nuts holding the unit to the banjo have been removed the complete differential unit can be withdrawn forward.

The pinion housing assembly can be removed as a unit, taking care not to lose the shims which are used for positioning between housing and differential carrier.

To dismantle, first remove the coupling locknut and pull off the coupling, which is keyed on to the shaft.

The housing cover and oil seal should then be removed, after which the shaft and rear bearing can be tapped out, leaving the front bearing in the housing.

Shims will also be found between the distance-piece and the front bearing—these are for bearing adjustment.

Bearings should be set so that there is no perceptible end float, but a check should be carried out after the coupling nut is refitted to make sure that the pinion will spin freely.

To adjust the differential bearings, the caps should be slightly slackened and the locking screws removed.

Each adjuster should be screwed in an equal amount until all play is taken up, although the bearings must not be nipped.

The pinion and crown wheel are lapped in pairs and numbered, and

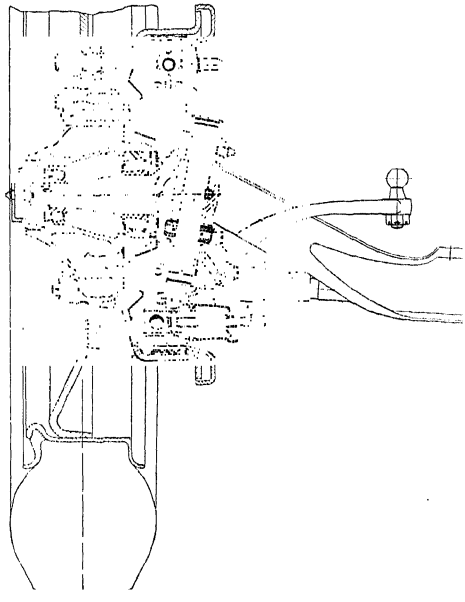


Fig. 7.—ARRANGEMENT OF FRONT-AXLE (TYPE N2)

at no time should a new crown wheel be fitted to an old pinion or vice versa.

If one component is in sound condition it should be returned to the makers, who will supply the necessary new part and lap them together.

When correctly adjusted, there should be approximately $\frac{1}{32}$-in. peripheral movement on the propeller-shaft coupling, with the crown wheel firmly wedged.

Bronze thrust washers are fitted behind the differential box pinions on the N5 and LN5, but not on the lighter models.

Rear Hubs

These are carried on the axle tube by means of opposed taper bearings, and present no special features.

When refitting oil seals, however, extreme care must be taken to see that these are not in any way damaged, either on the face or on the ground edge.

The hub should be examined carefully to ensure that there are no rags or burrs to damage the seal, and a coating of jointing compound should be applied to prevent possible leakage between the outside of the seal and the inside of the hub.

It should be pressed home with an arbor approximately ·015 in. less than the outside diameter of the seal, the sharp edge of the leather being towards the outside of the hub.

Front Axle

The general layout is similar on all types, although individual variations occur in respect of king-pin sizes, hubs, etc.

The king-pin is pressed into the beam and locked by a taper cotter, and it is essential that the king-pin is a driving fit. Oversize pins can be obtained + ·005 in., + ·010 in., and + ·015 in. when required, and where steel bushes are used similar oversizes are stocked.

Renewable bushes are fitted to the stubs, the thrust being taken by a Timken race on the lower face. Should it be necessary to fit new phosphor-bronze bushes, these must be reamered after they have been pressed in.

Hubs are carried on opposed taper races and present no difficulty in either dismantling or adjustment.

Steering

Bishop cam-type steering gear is used on all models, varying in size according to chassis type.

All track rods incorporate self-adjusting ball joints, and beyond periodic greasing no attention is required.

In order to assist in resetting the track at any time joints are threaded right and left hand, and it is necessary only to turn the track rod in the required direction after slackening off the clamping bolts at each end. Care must be taken to tighten the clamping bolts securely after the operation. Correct adjustment is $\frac{1}{8}$-in. toe-in. Always use the same point on the rim of the wheel for checking the distance between wheels, both at the front and at the rear.

On the N2, N3, and LN5 models, the side steering tube incorporates oilless cups, but the N5 has self-adjusting joints similar to those used on the track rod.

Brakes

Cowdrey brakes are fitted to all models except the N5, which are Bendix Duo Servo.

We would again stress that it is not possible to adjust the brakes by altering the length of rods or cables, all adjustment being by means of the geared expander in the drum.

If at any time the axles are removed, the brake shoes must be fully expanded in the drum and the cables well stretched, to remove any slackness, and the yoke should then be adjusted so that the clevis can be inserted but without allowing the cables to slack.

Details of the full adjustment are given separately, but we would again remind all users to insist on genuine replacement parts and at no time endeavour to reline existing shoes.

Tyre Pressures (all Models)

The following are the correct tyre inflation pressures for the various models :

8 cwt.—Standard size (5·25 × 16), front 25 lb. per sq. in.; rear 28 to 30 lb. per sq. in. An increase of 4 lb. per sq. in. in the rear tyres is recommended when the vehicle is to be driven fast or with full load.

15 cwt.—6·00 in. × 18 in. front and rear, single tyres, 40 lb. per sq. in. pressure.

N1.—6·00 in. × 20 in. front, 45 lb. per sq. in.; 32 in. × 6 in. truck, rear single, 75 lb. per sq. in.

N2.—6·00 in. × 20 in. front, 45 lb. per sq. in. ; 32 in. × 6 in. R.H.S. Single rear, 90 lb. per sq. in.

N3.—Standard 6.00 in. × 20 in., single front and twin rear, 45 lb. per sq. in. Alternative : 32 in. × 6 in. truck type, single front and twin rear, 75 lb. per sq. in.

N5.—34 in × 7 in., single front, twin rear, 95 lb. per sq. in.

LN5.—Standard 32 in. × 6 in. R.H.S. single front, twin rear, 90 lb. per sq. in. Alternative : 34 in. × 7 in., single front, twin rear, 95 lb. per sq. in.

For vehicles with twin rear tyres, even tyre wear is promoted by changing the position of tyres as follows :

1st position—front wheel.

2nd position—outer rear wheel.

3rd position—inner rear wheel.

REPAIR NOTES ON VAUXHALL CARS

THE REAR AXLE, BRAKES, AND STEERING

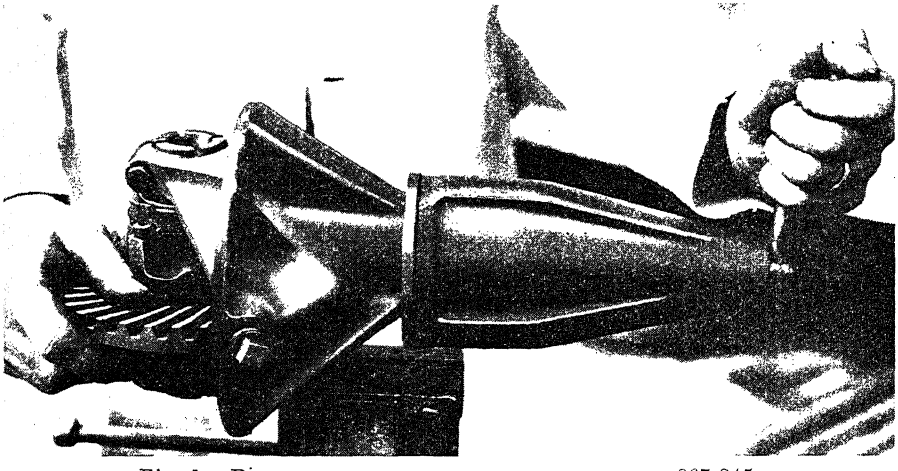


Fig. 1.—REMOVING BEVEL PINION, USING BRITOOL 867/845
If the tool is not available, remove pinion as described in text.

10-FOUR AND 12-FOUR

Rear Axle

THE rear axle of the 10-Four and 12-Four Vauxhall is of the semi-floating type, having spiral bevel final drive gears. The differential, being slightly offset, necessitates the use of axle shafts of different lengths; consequently the right-hand and left-hand shafts are not interchangeable.

Troubles that may be Met With

The following diagnosis will serve as a guide when dealing with complaints of rear axle trouble.

Axle Noisy

Insufficient or incorrect lubricant in axle.
Differential incorrectly adjusted.
Spiral drive pinion and gear teeth worn.
Bearings defective.

Axle Noisy when Cornering

Worn or chipped differential gears.

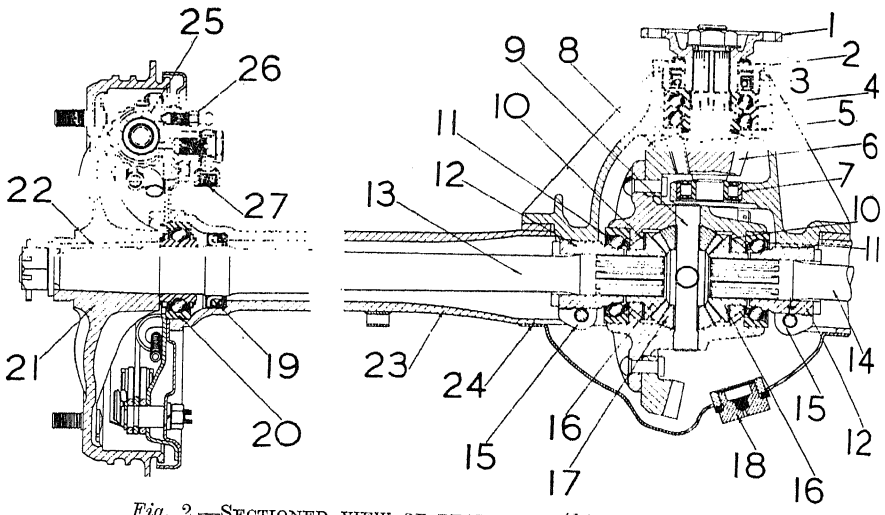


Fig. 2.—SECTIONED VIEW OF REAR AXLE (10-FOUR AND 12-FOUR)

1. Propeller shaft coupling flange. 2. Pinion adjustment locking ring. 3. Pinion oil seal. 4. Pinion front ball race. 5. Pinion adjustment shims. 6. Bevel pinion. 7. Pinion front support roller race. 8. Crown wheel. 9. Differential pinion spider. 10. Differential side gear thrust washer. 11. Differential ball race. 12. Differential ball race adjusting sleeve. 13 and 14. Axle shafts. 15. Adjusting sleeve locking plate. 16. Differential side gear. 17. Differential pinion. 18. Axle filler plug. 19. Axle shaft oil seal. 20. Axle shaft bearing. 21. Rear hub. 22. Key. 23. Rear axle casing. 24. Axle casing. 25. Back cover. 26. Brake cylinder bleeder valve screw. 27. Brake pipe-line connection.

Oil Leakage from Pinion or Past Rear Axle Shafts

Check breather in filler plug.
Worn or defective oil seal.
Axle over-filled with lubricant.

Rear Axle Shafts

To remove axle shafts, take out the split-pin and nut from the end of each shaft. Utilising a hub puller, draw off the rear hubs and brake drums. Disconnect the brake pipe-lines at the union on the rear face of the brake flange plate. Remove the brake backplate attaching bolts; the brake plate can now be lifted away as far as the hand-brake cable allows and rested on the spring. Withdraw axle shaft, using an axle shaft withdrawal tool (Britool No. 867).

Examine the shaft for signs of twist, cracks, or damaged splines.

As the oil seal is pressed into the axle casing it is not possible to remove this without damage, and if fitment of a new seal is necessary owing to leakage, the old seal can be extracted after splitting in half by means of a small sharp chisel.

To replace axle shafts, reverse the operations given for removal

Removing Differential Assembly

To remove the differential assembly, proceed as for the removal of the axle shafts, withdrawing shafts sufficiently to clear the splines of the differential side gears, and disconnect the propeller shaft at the rear universal joint coupling. Remove the eight bolts which attach the differential carrier to the axle casing and draw away the carrier.

Dismantling Differential Assembly

Release the differential adjusting sleeve clamp bolts and unscrew the sleeve out of the casing, then lift away the spiral drive gear and differential cage assembly.

Remove the clamp bolt which secures the bevel pinion adjustment locking plate and extract the locking plate.

Unscrew the bevel pinion adjusting ring out of the differential housing and withdraw the bevel pinion assembly.

When dismantling the bevel pinion assembly the oil seal can be tapped out of the adjusting ring, but as it would probably be damaged in the process a new seal should be used when reassembling.

The outer ring of the race may be left in the differential housing when the bearing is removed, and if so can be easily removed by tapping with a small drift.

Inspecting Differential Assembly

Examine the spiral drive gear and pinion for worn teeth and check the rivets attaching the spiral drive gear to the differential case for slackness. Check the splines of the pinion shaft for wear.

Examine the teeth of the differential pinions and side gear pinions and renew if chipped or worn. Check the bronze washers for scores and wear. The thickness of the washers is ·033–·031 in.

Check the gears for backlash, which should be ·006–·012 in.

Check the planet pinion spindle for wear or pitting.

Wash all bearings in thin oil and inspect for wear or pitted balls and seats. Even slight damage is intensified in the form of noise under operating conditions.

The differential carrier should not be distorted or cracked.

To Reassemble Differential Assembly

The assembly is straightforward, although it is essential that pinion adjustment shims are positioned correctly so that they are nipped between the casing and the outer race of the ball bearing when the locking ring is tightened.

Make certain that both the locking ring and universal joint flange nut are tightened securely, as otherwise a false adjustment may be obtained.

In order to provide the necessary resistance against turning when



Fig. 3.—METHOD OF USING UNIVERSAL JOINT LOCKING LEVER

tightening the coupling nut, a special tool can be easily made up out of $\frac{5}{16}$-in. mild steel plate. The tool when in use will bear against the vice whilst the nut is tightened (see Fig. 3).

To Adjust the Differential Assembly

With the assembly held firmly in a vice, the gears can be inspected for mesh. Adjustment should be made to obtain full-length engagement of teeth, smooth running, and a backlash between the spiral gear and pinion teeth of from ·005 to ·007 in.

Adjustment for this is obtained by slackening one spiral drive gear adjusting ring and tightening the opposite ring until the minimum amount of backlash can be felt.

When it is apparent that the spiral drive pinion is too far in mesh or insufficiently meshed, it will be necessary to remove the pinion and to remove or add shims. The shims available are of ·003 and ·005 in. thickness; consequently a close adjustment is possible.

Although it has the appearance of an adjusting sleeve, no adjustment can be made by simply tightening or slackening the pinion locking ring: shims must be added or removed, and the pinion locking ring finally tightened prior to checking the new position obtained.

To withdraw the pinion assembly for the purpose of altering the number of shims, slacken off the adjusting ring and at the same time gently tap the universal joint coupling flange with a copper hammer.

Having satisfactorily completed the adjustment for backlash, that for tooth contact must be made. It is absolutely essential to provide a load to the pinion shaft when rotating the gear.

Without this it has been found that an adjustment can be obtained giving a marking which resembles correct contact, but which invariably results in a noisy axle when assembled.

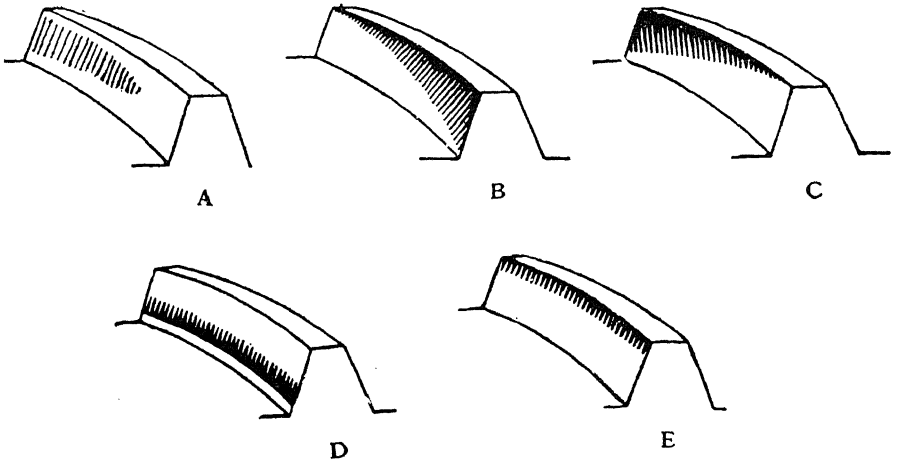


Fig. 4.—SPIRAL GEAR ADJUSTMENT DIAGRAM

A.—Correct contact. B.—Heavy contact on inner end of tooth—correct by moving spiral drive gear towards pinion, retaining specified backlash, if necessary, by moving pinion outwards. C.—Heavy contact on inner end of tooth—correct by moving spiral gear away from pinion, maintaining the backlash by moving in the pinion if necessary. D.—Heavy contact along root of tooth—correct by moving pinion outwards. E.—Heavy contact peak of tooth—correct by moving pinion inwards.

A sufficiently effective load can be obtained if a 4-in.-diameter circular plate having rounded edges be turned and drilled for bolting up to the universal joint coupling flange. This provides a comfortable grip for the hand.

A brass plug with a $\frac{5}{16}$-in. S.A.E. thread should be screwed into the tapped drilling provided in the differential casing, so that the side and planet gears cannot rotate. In order to turn the spiral gear, a handle should be made up and inserted to engage with the splines of one of the differential side gears.

The teeth of the spiral drive gear should be given a light coating of engineer's marking blue in two or three positions around the gear and covering at least six teeth in each place.

The gear must be rotated in both directions. To ensure quiet running and minimum wear, the bright marking which compares with the shaded area at " A," Fig. 4, should be obtained.

The markings should appear in this form on both sides of the teeth—i.e. on " drive " and " over-drive." It will probably be found that the bright markings will not conform to " A " at the first attempt ; they will probably approximate to the form of one of the other markings shown in Fig. 4. In this case adjustment must be made as indicated against the diagrams until the marking at " A " is obtained, together with backlash within the limits ·005–·007 in.

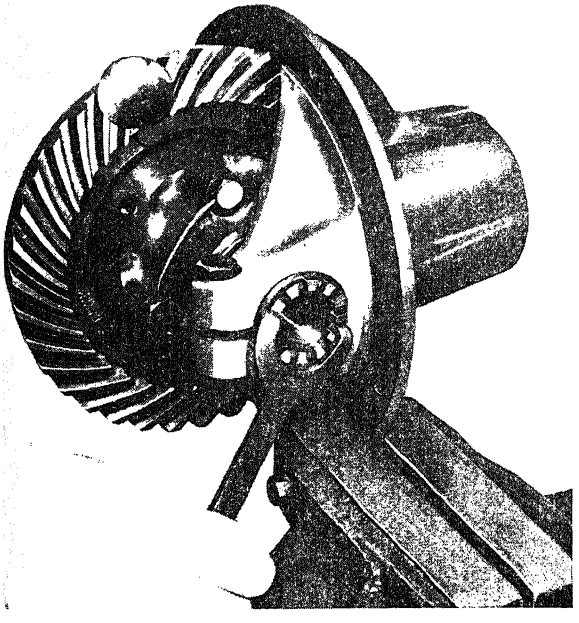


Fig. 5.—DIFFERENTIAL SIDE BEARING ADJUSTMENT
Note the plasticine fixed to the outer edge of the spiral bevel gear

Throughout these checking operations do not omit to apply pressure to the hand grip on the drive pinion.

The final adjustment is that of the differential thrust races. This is extremely important and has a distinct effect on the resultant quietness of gear operation.

Remove the brass plug from the differential casing and the hand-grip from the universal joint coupling.

Withdraw the spiral drive pinion. Fix the differential carrier in the vice, holding it by one of the webs so that the spiral bevel gear is in the vertical plane.

Affix half an ounce of plasticine to the outer edge of the spiral bevel gear (Fig. 5). The use of this is to provide an accurate guide for testing the adjustment of the differential thrust races.

The sleeves should be tightened only to an extent that will allow the weight of the plasticine to slowly turn the gear. This test should be carried out in both directions of rotation and in several positions.

This operation does not affect the previous meshing adjustment, inasmuch as the adjusting ring rotation required to obtain this final setting will be extremely small; when the foregoing is satisfactorily completed, tighten the sleeve-clamp bolts, replace the spiral drive pinion, and thoroughly tighten the locking ring.

Lock the latter in position with the locking plate, which will be seen to be formed with a single and double tongue, so that movement of half a castellation is sufficient to allow engagement. Slide on the coupling, thoroughly tighten the nut, and turn up the locking washer.

To Renew Spiral Drive Gear

The spiral drive gear and pinion are serviced in matched pairs, as it is not satisfactory to attempt to fit a new pinion to a worn gear or *vice versa*.

Remove the spiral drive gear rivets by drilling through the head. A $\frac{1}{4}$-in. drill will be required. Do not attempt to take off the heads of the rivets with a chisel.

Drill through from the flat head of the rivet in order to assist the operator to keep in the centre of the rivet shank. In order to avoid damage to the differential case holes and when drilled through sufficiently to weaken the rivet heads, cut off the shell of the heads with a chisel and punch out the rivets.

After the gear is removed, centre the case in a lathe and check for run-out. A maximum of ·002 in. is allowed, and if in excess of this, true up.

Clean all burrs from the rivet holes and the faces of the case and the gear, bolt the gear tightly to the case, using four well-fitting bolts.

The riveting must be done cold in a suitable press.

The spiral drive gear is secured to the differential case by means of the four bolts already mentioned, whilst the first few rivets are inserted into position. Rivet on alternate sides of the circumference, so that it will not be drawn out of truth.

The rivet heads naturally must be formed on the casing side and must not extend for more than $\frac{5}{8}$ in. from the face of the ring gear.

On completion of the riveting, the back face of the spiral drive gear should be checked with a dial gauge for run-out, which must be within ·0035 to ·005 in.

Rear Springs

The rear springs are of the semi-elliptical type. Rollers are fitted to prevent squeaks developing, two of these being threaded in order to act as bolts to which the two spring clips are secured by castellated nuts and split cotter pins.

The spring is attached to the axle by U bolts, special rubber insulators being interposed between the upper and lower clamp plates.

The special bumper is also clamped to the top of the axle casing by the U bolts. At both the front and rear ends of the spring the top leaf is turned back to form an eye into which a " Silentbloc " bush is pressed and retained by peening over in four places. It will be noticed that the bent-over portion of the eye is in tension and clear of the flat of the spring leaf.

After removing the springs, examine the spring leaves for signs of cracks and check the assembly for camber, which should be $\frac{1}{8}$ in. reverse.

The " Silentbloc " bushes should be renewed if perished or in any way deteriorated. These can be easily renewed by pressing out the old bush assembly or alternatively by forcing out with a suitable drift.

The new bush should then be pressed into position and peened over in four places.

When springs are reassembled after dismantling, fit the nuts to the

shackle bolts, but do not fully tighten. The rear of the car should then be bounced two or three times to allow the " Silentbloc " bushes to take up the correct position, after which the nuts can be tightened and split-pinned.

Rear Shock Absorbers

The rear shock absorbers are of the single-acting hydraulic type.

All service work on the rear shock absorbers (with the exception of topping-up) must be carried out with the absorber removed from the car.

When servicing, examine for slackness of the shaft in the casing and also for end float on the cam lever. This should be ·025 in. maximum.

Other than attention to the piston, piston return spring and relief valve, it has been found that the cost of labour and material in reconditioning these shock absorbers is equal or more than the price of new assemblies.

The pistons and cylinder walls must be free from scores. Check also the pistons for wear on the face which contacts the inlet valve seating. The valve cannot be dismantled, and therefore any question as to its efficiency can only be satisfactorily answered by replacement.

LIGHT SIX, 12 H.P. AND 14 H.P. (MODELS D)

Removing Rear Brake Drum

To avoid risk of damaging the brake shoes, slacken off the adjustment. Remove the three countersunk screws attaching the brake drum to the flange of the axle shaft, when the drum can be pulled over the wheel attaching bolts by hand. Two tapped holes in the brake drum permit the use of an extractor if necessary.

To Replace

The attachment screw holes in the brake drum are unequally spaced, so that the holes in the drum and the hub must be brought into line before the drum is passed over the wheel attachment bolts.

If the brake adjustment has been released, do not omit to readjust the brakes.

Removing the Axle-Shaft Assembly

Slacken off the six nuts and lock washers which attach the retaining plate to the casing. The nuts can be completely removed, utilising the special hole for this purpose provided in the axle-shaft flange.

In most cases it will then be possible to draw the axle-shaft assembly out of the housing, but if the fit of the ball race in its housing prevents easy withdrawal a drag of suitable type (Britool Drag No. 882) will be required.

A shrinkage fit holds the retaining collar on to the axle shaft.

If it is required to remove the collar, it will be necessary to turn it off in a lathe. An extractor will be required to remove the bearing when the other parts can be removed and the axle shaft and component parts are ready for inspection.

Renew the oil-retaining seal if worn or, if prior to dismantling, oil leakage has been evident.

Make certain that the surface of the retainer plate is perfectly flat, and also that no slight irregularities prevent it from seating.

To Reassemble

Carefully affix the paper gasket to the oil deflector, using a good jointing compound. Thread the oil deflector and retainer assembly on the shaft and then press the bearing on to the shaft followed by the special spring washer. As the bearing retaining collar is a shrunk fit on the shaft, the new collar must be brought to a heat of 300–350° C. (dark blue coloration) before being pressed into position. Note that these parts must be assembled solidly on to the shaft, no side play of the bearing being permissible.

Allow the collar to cool off in the air and lubricate the bearing.

To Replace

Insert the shaft and engage the inner end splines with the differential gear. Locate the retaining plate squarely in the end of the housing and tighten the attachment nuts evenly and thoroughly.

Differential Carrier Assembly

To remove, see preliminary instructions for the 10-h.p. model.

Assist the carrier from the housing with the hands and the application of light blows with a lead hammer.

The differential carrier bolts will remain fixed in the housing, and care must be taken to prevent the bolt threads being damaged as the carrier is drawn off.

Before *dismantling* the differential assembly the work will be considerably simplified if the differential carrier is mounted on the bench on three support tubes and long bolts, which, if made up for the purpose, will be found of considerable use whenever differential adjustments are being made.

Mark the differential carrier caps to ensure that they are refitted correctly.

On vehicles which have covered an appreciable mileage, all four differential gears should be either suitably marked or placed on the bench in such a manner that they may be replaced in the same position as they previously occupied.

If it is necessary to remove the differential side bearings, a drag will be required.

To inspect the differential carrier assembly, see instructions for the 10 h.p. model.

When replacing the differential-carrier assembly, always fit a new gasket between the differential carrier and the axle housing.

To Adjust Spiral Drive Gear

It is difficult to lay down a specific rule for controlling the backlash between the spiral drive pinion and the gear. However, the quietest running and the longest life of the gears will be obtained if this backlash is maintained within the limits of ·004 and ·008 in. Check this clearance by the insertion of feeler gauges between the engaged teeth.

Having adjusted the pinion by means of the outer and inner adjusting sleeves provided to give as near as possible full tooth bearing, proceed with the adjustment in the following way :

If the backlash is too great, slacken back the adjusting ring several turns and the whole of the differential assembly by tightening the opposing adjusting ring. This brings the spiral drive gear into closer mesh with the pinion.

This operation is naturally reversed if the gears are too tightly in mesh, i.e. the adjusting ring on the back side of the spiral drive gear is unscrewed several turns and the other ring adjusted up until the requisite backlash is obtained.

The final operation is very important.

The adjusting ring which was first screwed back several turns may now be brought up until it contacts with the outer races of the bearing and induces this race to turn with it. This is the correct adjustment, and both adjusting rings are therefore locked in this position by the lock. The differential bearing can now be thoroughly tightened.

To Renew

The differential side bearings are removed by means of an extractor.

Before attempting to fit a new spiral drive gear, the face of the differential case must be checked for running true. If this face runs out of truth more than ·003 in., skim it up in a lathe.

The spiral drive gear is bolted to the differential case with four bolts whilst the first few rivets are inserted into position.

Check with a dial indicator on the back face of the spiral drive gear after fitting, allowing a maximum run-out of ·003 in.

N.B.—New spiral drive gears are always supplied together with a matched spiral drive pinion. Never replace one without the other.

Carefully remove any splinters of metal which may have broken away from the rivet heads during riveting.

Refit differential side bearings.

In addition to the foregoing, see also renewal instructions for the 10-h.p. model.

To Inspect

Examine the thrust bearing for wear after washing with thin oil (not paraffin).

This bearing must not have the slightest slackness, as it is responsible for carrying the whole of the thrust load, as well as a proportion of the journal load, the combined factor of which is frequently very high.

Also examine the cage of this bearing for signs of fracture, due to wear, and replace the bearing if any such evidence exists ; any breaking up of the cage of this bearing will result in pieces dropping into the axle and causing damage, which may be of serious consequence.

Examine the teeth of the pinion and renew if excessively worn.

N.B.—Spiral drive pinions and gears are supplied in matched pairs, and a new pinion should never be fitted without renewal of the spiral drive gear.

Examine the oil seal fitted in the pinion front adjusting sleeve and renew if the leather is excessively worn or hard.

Check the pinion rear bearing for wear.

Before replacing the outer adjustment sleeve of the pinion, the oil seal incorporated in this should be soaked for two hours in a light mineral oil at a temperature of approximately 100° F.

Steering Gear

The steering gear from chassis Nos. DX 655401 and DY 514001 onwards is Burman Douglas. Particulars of adjustment of this type will be found in Vol. I. Chassis prior to the above numbers was fitted with worm and sector form of steering having the following adjustments.

To Adjust End Float

At the back of the steering box will be found an adjusting screw, secured by a locking nut. This screw is for the purpose of adjusting the end float on the drop-arm shaft. Loosen the locknut and tighten the screw until contact is made with the drop-arm shaft, when the locknut should be retightened.

To Adjust Backlash between Worm and Sector

A bolt and sleeve secure the drop-arm shaft housing to the steering box. The sleeve is eccentric, enabling adjustment to be made to overcome the backlash between the worm and the sector. The sleeve is provided with a hexagon nut.

To adjust, turn the bolt in a clockwise direction to decrease, and an anti-clockwise direction to increase, the backlash. The bolt should be turned by means of a spanner until, when gently turning the steering wheel backwards and forwards, a tight spot can be felt just as the front wheels pass the straight-ahead position. Whilst carrying out this operation the sleeve hexagon should be held stationary with another spanner.

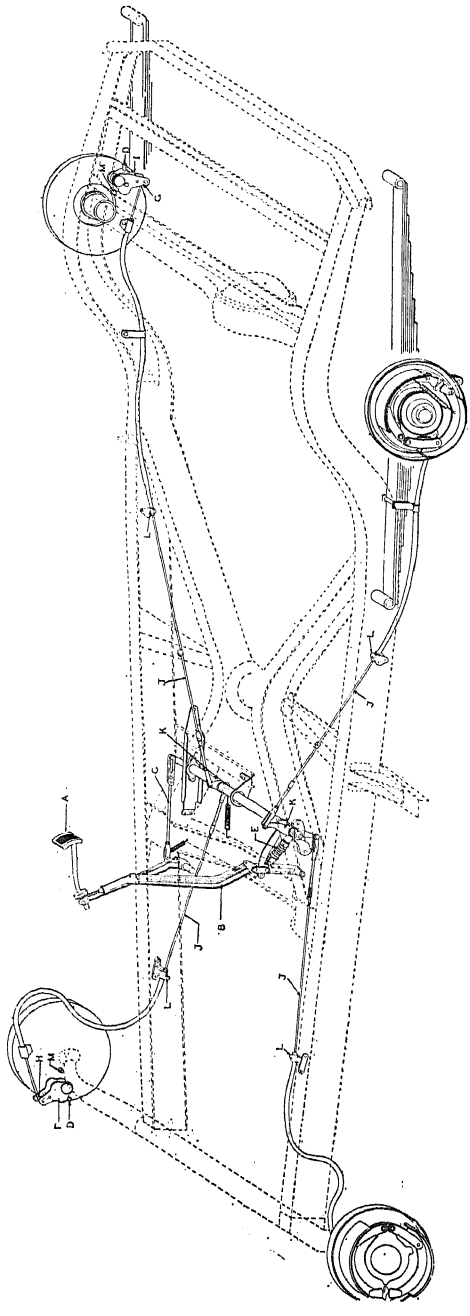


Fig. 6.—FOUR-WHEEL BRAKE LAYOUT (LIGHT SIX, 12-H.P. AND 14-H.P.)

If it is not possible to take up the backlash sufficiently by means of the eccentric bolt, turn back the bolt to a position which gives the greatest degree of backlash, and then rotate the sleeve until most of the backlash is taken up. Very fine adjustment can then be made with the bolt.

When reassembling the steering box after dismantling, the drop arm must be replaced on the drop-arm shaft in the correct position. For this purpose lines will be found marked both on the drop arm and the shaft, which should coincide.

To Adjust End Float in the Steering Column

Adjustment for end float of the inner column is provided by an adjusting plug, which will be found located between the steering box and the outer column.

To carry out this adjustment, slacken off the column support clamping bolt and the clamp bolt on the top of the steering-box casing, after which the adjusting plug nut is screwed down until it is possible to spin the wheel freely, but without any trace of binding in the column.

Adjusting Braking System

The four-wheel brakes on the Light Six, 12-h.p., and 14-h.p. Models D are

of the mechanically operated semi-servo type, servo action being obtained by a link arrangement attached to each shoe, by which full contact of the shoes with the drum is obtained. On applying the brakes, the rotation of drum itself reacts upon and increases the pressure of the shoes to drum.

When possible, it is better to lift all four wheels when carrying out adjustments. All the four must be given attention.

Set the hand-brake lever (B) (Fig. 6) in the fully off position and screw the adjusting screw (D) of each brake until the shoes are binding hard on the drums. Tap the centraliser bolts (M) to ensure that the centralisers are free to move. This operation centralises the brake shoes in relation to the drum, after which the brake-shoe adjustment screw (D) must be unscrewed just sufficiently to allow the drums to rotate freely after application of the brake pedal.

On completion of these adjustments, the vehicle should be tested on the road, and if it is found that the braking is uneven, slacken off the adjustment screw (D) of the brakes which bind the harder until even braking is obtained.

Resetting the System

The brake-operating system is correctly set when the car is new. Do not interfere with this setting, therefore, unless the whole system has previously been disturbed or the vehicle has sustained accident. Never shorten the brake-operating cables to compensate for wear on the brake-shoe liners. However, if the system has been disturbed, the following work will be required.

Disconnect the front- and rear-brake cables from the levers (K) on the cross-shaft and also the foot-brake pull-rod (C). Set the foot-brake pedal in the fully off position up against the toe-board and adjust the brake-pedal pull-rod (C) so that when connected there is no slack in the hand-brake thrust link (E).

Set the front- and rear-brake cam levers (F) and (G) against their stops (H) and (I), tap the centraliser clamp bolts (M) to make sure that the centralisers are free to move, and tighten the adjusting screws (D) until the shoes are binding on the drums.

The front- and rear-brake cables should now be adjusted until the clevis pins can just be inserted through the cable yoke ends and the levers on the cross-shaft without slack in the cables, yet without lifting the levers (F) and (G) from the stops. Slacken off the adjusting screws (D) until the road wheels will revolve freely. The final setting should be made on the road or brake testing machine.

The maximum allowable drum ovality is ·006 in.

VAUXHALL 25-H.P. (MODEL G)

Removing Rear Axle Shafts

Remove the axle housing inspection cover. Take out the planet pinion spindle lockscrew (14) (Fig. 7) and withdraw the spindle (16) so

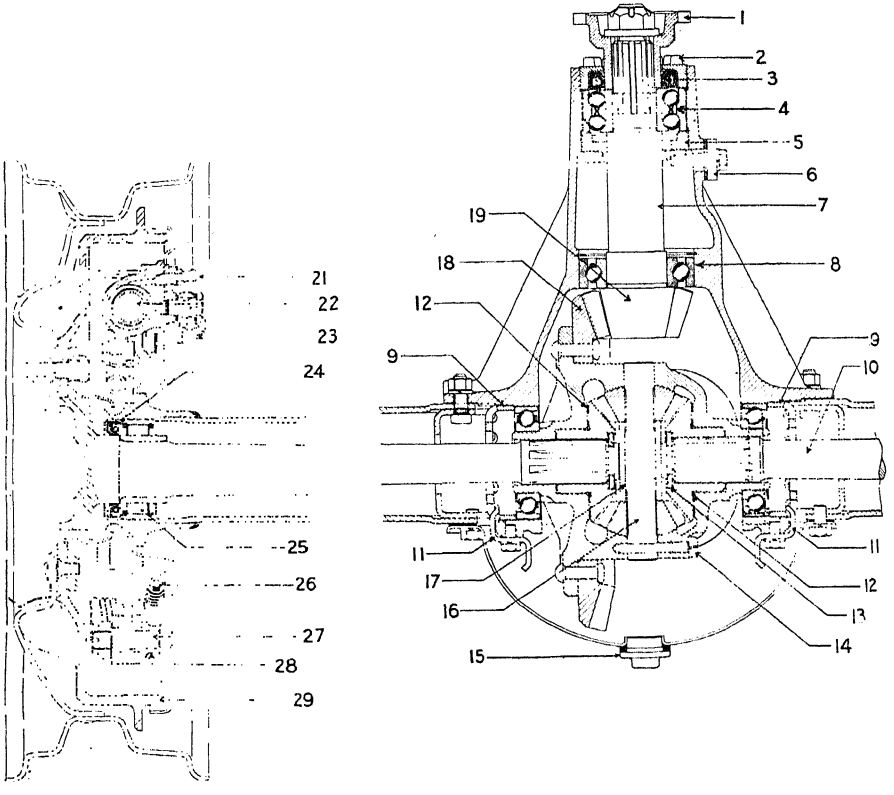


Fig. 7.—SECTION OF REAR AXLE

1. Propeller shaft coupling flange. 2. Pinion front adjusting ring. 3. Oil seal. 4. Double row ball thrust bearing. 5. Pinion rear adjusting ring. 6. Adjusting ring locking plate. 7. Pinion shaft. 8. Ball bearing. 9. Differential carrier adjusting sleeve. 10. Rear axle shaft. 11. Spiral drive gear adjusting sleeve locking plate. 12. Differential side gear thrust washer. 13. Axle shaft retaining collar. 14. Planet pinion shaft lock screw. 15. Filler plug. 16. Planet pinion shaft. 17. Axle shaft spacer. 18. Spiral drive gear. 19. Spiral drive pinion. 20. Spring saddle. 21. Brake cylinder bleeder screw. 22. Brake cylinder. 23. Brake cylinder pipe union. 24. Oil seal. 25. Roller bearing. 26. Hand brake operating cable. 27. Brake shoe anchor link bolt. 28. Brake shoe anchor link bolt spacer. 29. Brake drum.

that the axle shaft spacer (17) can be removed Push inwards the brake drums in order to release from the counterbores in the side gear the horse-shoe washers, which can then be pulled from the grooves in the axle shafts. The shaft with brake drums attached can now be withdrawn from the housing.

Where wear on the brake drums has been sufficient to form a groove, the shoes are likely to bind unless the brake adjustment is first slackened off.

Remove the drums by taking out the three retaining screws.

To Inspect

Inspect the condition of the oil seals. Renew the seals if, prior to dismantling, there were signs of oil leakage. These seals are held in position on the ends of the axle housing by centre punch-marks. The easiest method for removal is to clean off the punch-marks and then to use a drag and pull out the axle shaft bearing, which will bring with it the seal.

Examine the axle shaft spacer for wear. Unless the spacer permits a minimum amount of end float of the axle shafts, a knock will result. There are three sizes of spacer available.

Part No. 1036667F . . .	1·160/1·161 in.
1036667H . . .	1·164/1·165 in.
1036667K . . .	1·168/1·169 in.

Intermediate sizes may be obtained by carefully rubbing down, using emery paper and a surface plate, or by grinding.

To replace, reverse the operations given for removal.

Differential Pinions and Side Gears

Check the bronze washers for scores and wear. The thickness of the washers is ·032–·031 in.

Check the gears for backlash which should be ·006 in.

To Reassemble

When assembling the side bearings to the differential casing, before pressing on to the spigots make certain that these are free from burrs. It is important to assemble them with the side marked THRUST outwards.

To Adjust

Adjustment should be made to obtain a backlash between the teeth of from ·004 to ·008 in.

If it is necessary to move the spiral drive pinion in or out, either the front or rear locking ring (Fig. 7) must be slackened off, according to the direction in which the pinion is to be moved, and the opposite ring tightened.

Similarly, the spiral drive gear can be adjusted, but in this case a final adjustment is necessary. The adjustment ring which was first screwed back when the final meshing adjustment was made must now be brought up until it contacts with the outer race of the bearing and induces this race to rotate with it. *Immediately* this occurs, the adjustment is correct and the adjustment rings must be locked into position by the ring locks and the bearing-cap bolts tightened.

Having obtained smooth running with correct backlash, it is desirable to check the contact of the teeth.

Proceed according to the instructions for the 10-h.p. model.

Adjustments for teeth contact must be made as indicated against the diagrams until the marking at A is obtained, together with backlash within the limits of ·004·008 in. The gear teeth must be "re-blued" before each test. When a satisfactory result is obtained, remove the turned-down joint and continue with the reassembly operations.

For *renewing* the spiral drive gear, see instructions for 10-h.p. model.

A later article in this volume deals with the 14-h.p. "J" model Vauxhall and with the changes occurring on later 10-Four and 12-Four models.

CELLULOSE REFINISHING FOR THE MOTOR TRADE

By H. J. CURTIS



Fig. 1.—APPLYING THE FILLER COAT
Note masking paste on window to prevent material adhering to glass.
(*By courtesy of Provincial Sheet Metal Works, Cheam*)

THE aim of this article is to give advice, in a very condensed form, and as many hints and tips as possible to the cellulose operators in the motor-car cellulose refinishing business. The subject covers a very large field, so the writer will deal with it as briefly as possible, and right to the point in many cases, using simple terms which may be readily understood by beginners and experts alike.

The Spraying Equipment Required

Before dealing with the various methods of application, some advice on the spraying equipment is necessary. There are various spray plants on the market, many of which are of the small " touch-up " variety.

Whilst these small plants may be quite suitable for work such as touching-in small spots on wings, panels, etc., they are most certainly not suitable for complete refinishing. It is advisable, therefore, that anybody contemplating an entry into the cellulose business should start well by purchasing the right type of plant.

Position of the Exhaust Fan

The cellulose operator is usually interested to know whether the continued use of these materials is in any way detrimental to his health. All paint material, whether cellulose or otherwise, if breathed in sufficient quantities, would have undesirable effects. Providing, however, that reasonable precautions are taken, such as correct ventilation and exhaust-fan arrangements, there is no likelihood of any ill results. With regard to the exhaust fan which must be fitted in all spraying-booths and paint-shops, the necessity of having this fitted near the floor is often overlooked. The reason for this low position is that vapour (or cellulose fumes) is approximately three times heavier than air. Thus a fan fitted several feet from the floor would fail to exhaust the fumes in a satisfactory manner. The law, under the Factory Act, says that the air in a paint-shop must be changed thirty times an hour. In the same way that the fan protects the health of the operator, it also reduces the risk of fire and explosion. It must be remembered that these materials are highly inflammable in nature, and a "No Smoking" notice should be prominently displayed.

Avoiding Trouble with Materials

It should here be stated that it is a great mistake to mix various manufacturers' material, i.e. to use one make of primer, another make of filler, etc. Manufacturers spend many thousands of pounds annually on research work. To destroy deliberately this valuable information, which is given free to users, is foolish, to say the least of it, and is the frequent cause of trouble. Remember, when carrying out the work, to complete it with one manufacturer's products.

METHODS OF REFINISHING A CAR

For the benefit of those whose knowledge is very limited, the following are the usual methods by which a car is refinished from the bare metal upwards. There are two methods by which a car can be refinished. The first is by using oil-base undercoats, followed by the cellulose colour. The second by using cellulose-base undercoats, also followed by cellulose colour. The former method is usually recommended, due to the fact that oil-base materials have better adhesion, more elasticity, and better filling properties, but the drying times are very much longer. However, as speed is of such paramount importance to-day, the use of cellulose undercoats is almost universal in the refinishing shop.



Fig. 2.—FILLING AND STOPPING REPLANISHED WING PRIOR TO RUBBING DOWN AND FLATTING
(By courtesy of the Provincial Sheet Metal Works, Cheam)

A comparison of oil-base and cellulose undercoats is as follows :

Oil Primer
Drying time 12 hours.
Oil Filler
Drying time 4 hours between coats.
Oil Stopper
6 hours.

Cellulose Primer
Drying time 30 minutes.
Cellulose Filler
Drying time 30 minutes between coats.
Cellulose Stopper
1 hour.

Removing Old Paint

In the first place, all the old material should be removed by one of the many paint removers on the market. Care should be exercised in the cleaning down of the body after stripping. A good method is to wash off with petrol to remove any trace of the paint remover. Failing to do this thoroughly, trouble may result in the non-drying of the subsequent coats applied.

Dealing with Rust Spots

Should any rust spots show themselves, treat these with rust remover. Allow this to remain for a few minutes, then scour the surface with emery and finally wash off.



Fig. 3.—FRONT VIEW OF CAR, MASKED AND ALREADY SPRAYED WITH FILLER
The operator is working with rubber pad covered with abrasive paper to ensure flat surface, prior to first coat of cellulose enamel.



Fig. 4.—OPERATOR APPLYING FIRST COAT OF CELLULOSE ENAMEL TO PANELS OF CAR
(By courtesy of the Provincial Sheet Metal Works, Cheam)

Spraying the Filler Coats

The next step is to spray the primer coat. Having arrived at the spraying stage, it should be noted that all cellulose materials are applied at a pressure of approximately 55 lb. This pressure can be varied to the extent of a few pounds either way, with a minimum of 45 lb. Filler coats are now applied, the number of coats depending entirely on the condition of the body. With modern panel work, three coats are usually sufficient.

After the First Filler Coat—Stopping

After the first of these has been applied, it is necessary to fill in all dents and imperfections with knifing stopper, remembering that this must never be heavily applied. Should a dent be deep, two or more spreads must be used.

Wet-sanding

Now apply the second filler coat and successive coats, as deemed necessary, leaving the last coat overnight to harden out thoroughly before wet-sanding.

Applying the Colour Coats

The colour coats are now applied ; three coats, generally speaking, being sufficient. After the last of these, the job should be allowed to remain for four hours, and then wet-sanded with a fine grade of abrasive paper.

Eliminating Sanding Scratches

Dry off thoroughly and overspray with a coat of thinners, to which may be added a small percentage of the colour. This is to eliminate slight scratches caused by the sanding operation.

Polishing

Some hours should be allowed to elapse before polishing with smoothing compound, and the job is finally brought to a high lustre by the use of a liquid or wax polish. Hints on polishing are given on p. 200.

REPAIR WORK

The principal work in the refinishing shop to-day, however, is that of carrying out repair work, due to accidents. Difficulties are experienced here, principally due to the fact that the bigger mass-production manufacturers are using materials other than cellulose for finishing their bodies. Synthetic stoving enamels are largely used to-day for this purpose, and unless the refinishing shop is equipped with stoving lamps which will enable them to use a similar material, the use of cellulose is the only satisfactory alternative. It is not always possible to apply cellulose direct to these baked surfaces without experiencing trouble in the form

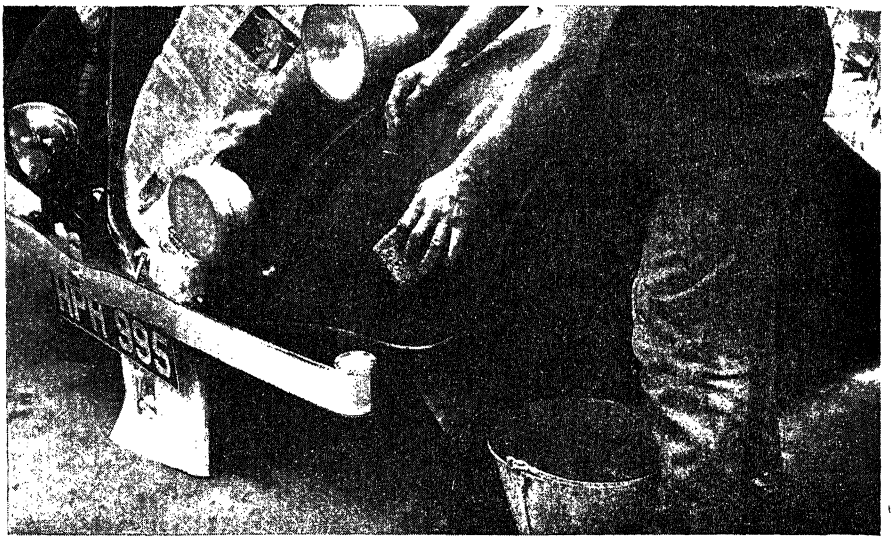


Fig. 5.—FLATTING DOWN WING WITH ABRASIVE PAPER IN PREPARATION FOR FINAL COAT OF CELLULOSE ENAMEL

(*By courtesy of the Provincial Sheet Metal Works, Cheam*)

of boiling up or splitting. So the most essential thing is correct preparation, which can be effectively carried out with the use of cellulose surfaces. These materials will seal or isolate the stoved surface, thus preventing the troubles previously mentioned.

Applying Cellulose to Enamel

To carry out a repair of the above nature, first clean the affected panel or wing, etc., with petrol to remove any polishes or grease. Then wet-sand the fracture, extending to an inch or so all round. Spray one coat of surfacer and then stop up if necessary. This is followed by two or more coats of surfacer. Allow the final coat to harden, and wet-sand with abrasive paper. Now apply the colour coats, extending each coat slightly farther than the previous one. Proceed with the smoothing and polishing operations as previously described.

Refinishing Over Old Cellulose

Whilst on the subject of repairs and troubles ensuing from the use of cellulose over synthetic surfaces, this trouble and also that of refinishing over old cellulose are experienced in the paint-shop. Even experienced operators are troubled to a great extent by this, and in many cases do not know why it happens or how to overcome the trouble. What actually happens is that the film of cellulose loses its elasticity through exposure,

and therefore goes hard and brittle. When the new lacquer is applied over this, it has a strong solvent action on the old film, thereby softening it, and in the drying it is unable to give or flow to the extent of the new lacquer, which causes it to split. The effect on the finished job is that of innumerable scratch-marks.

To overcome this trouble it is necessary to seal up the old film, and for this purpose a cellulose surfacer must be used in which the solvent is of a slower-drying type. A surfacer of this kind will not have such a fierce paint-remover action as the ordinary material, and will only penetrate the surface sufficiently to get a good key and will dry off slightly slower. It will be found that old cellulose surfaces treated in this manner will not give trouble.

The surfacer mentioned must not be confused with the ordinary type of cellulose primer surfacer, although it is naturally similar in many respects. The material must be very elastic and flexible, so that stresses set up by the old lacquer coats are absorbed by it and not transmitted directly to the new lacquer. It contains special ingredients together with a fairly high percentage of pigment, which definitely acts as a buffer coat between the old and the new cellulose surfaces.

The most important point to note is that in applying this material over an old lacquered surface, it is always advisable to apply a mist coat



Fig. 6.—FINAL COAT OF CELLULOSE ENAMEL BEING SPRAYED ON WING

Note masking on panels to prevent cellulose from being sprayed on panels which are of a different colour. (*By courtesy of the Provincial Sheet Metal Works, Cheam*)

and then follow with a normal coat. It should further be added that when the material is going to be flatted, a further coat will be necessary, otherwise the flatting operation will remove this protecting or buffer coat, allowing the finishing coats of lacquer to penetrate into the old lacquer resulting in the original trouble.

Cellulosing Wood

The foregoing remarks have applied to the use of cellulose on metal, and although the necessity of applying cellulose to wood on the modern motor-car is almost extinct (owing to all-steel bodies), at the same time the spray-shop is sometimes called upon to do so. It must always be borne in mind that the attendant risk of the cellulose cracking and coming away wherever there is a joint or screwed-on moulding is considerable. Furthermore, it will flake off to the bare wood. This is sometimes due to unseasoned wood or to the fact that the strain and vibration set up by the moving vehicle causes the wood to whip.

Therefore, whenever it is necessary to cellulose the external wood parts on a body, always use oil-base undercoats, which will allow for a slight amount of movement to a greater degree than would the harder cellulose undercoats.

A good tip, whenever cellulose on wood is undertaken, is to take equal parts of linseed oil and turpentine, mix together, and rub hard into the wood with a piece of coarse rag, any surplus remaining on the surface being wiped off and the job left overnight. Proceed the next day with a coat of oil primer followed by the usual oil filler.

It will be found that wood treated in this manner is more likely to be satisfactory when cellulose is applied. Still further, in the case of wood, it should be known that it is necessary for wood to breathe, so for this purpose, if it is possible, do not paint the back.

Repairing Polychromatic Lacquer Finish

A method of finishing which is becoming more popular is that of the polychromatic lacquers, sometimes known as scintillating or opalescent. The scintillating effect which these lacquers give is obtained by the addition of metal powders to the lacquer. From the paint-shop angle these finishes have several snags when they come in for repairs, the principal one being that they are very prone to appear patchy or shady. This is due to the fact that in the polishing operation, heat is generated, which tends to tarnish or blacken the fine metal particles. If it were possible to use the same amount of pressure all over the job, which of course it is not, then it would not matter. So, to overcome this trouble, some mass-production manufacturers apply coats of clear lacquer over this finish. This lacquer is polished, thus obviating the trouble. But the use of clear lacquer is not to be recommended, because the durability of this material is not as good as the pigmented type.

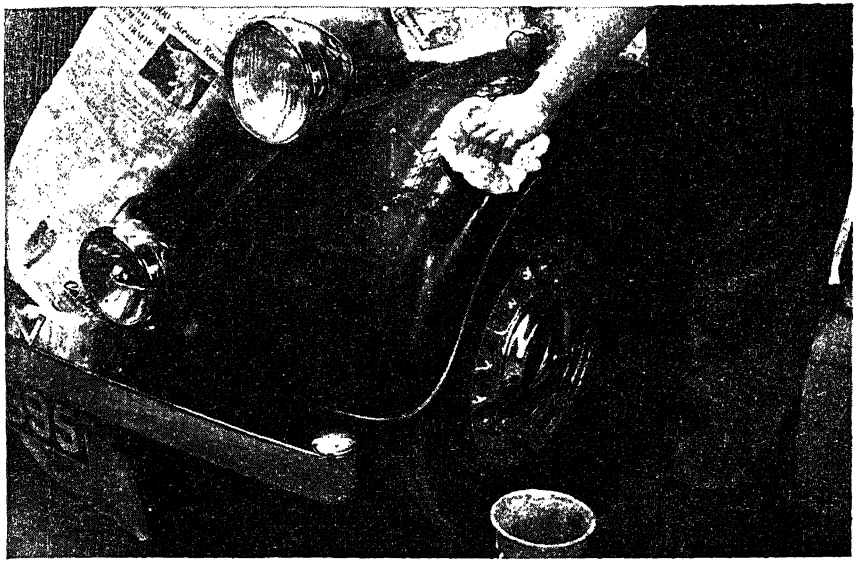


Fig. 7.—PUTTING A FINISH ON A CELLULOSED WING

An abrasive compound is first used and a high gloss is then obtained with a finishing polish. (*By courtesy of the Provincial Sheet Metal Works, Cheam*)

Avoiding Patchy Effect

The best method is as follows : After the last coat of polychromatic lacquer has been applied, overspray with two further finishing coats, which should be nearly all thinners, to which is added a small percentage, say 20 per cent., of the polychromatic lacquer. It will be found that if the job is done in this manner it can be polished in the ordinary way without the " shady " effect being noticeable.

Matching

A still further trouble with this particular finish is that of matching. Polychromatic finishes fade rather more than straight-pigmented lacquers, and it is for this reason, coupled with the fact that the metal powder in the lacquer tarnishes, that in many cases it is almost impossible to get a dead match in the case of spotting in or repair work.

Renovating Fabric Bodies with Cellulose

Although fabric-covered bodies are almost a thing of the past, at the same time it is necessary that every operator should know the correct way to renovate this material with cellulose. It is not all types of fabric

that are suitable for cellulose, for example those made on a rubber base. Test by spraying a small portion (in an out-of-the-way place) and examine when dry. If the surface is free from shrivelling and cracking it will be safe to go ahead with the job.

In the first place, specially prepared enamels are needed. They yield a flexible film with a suitable degree of gloss straight from the gun, as it is impracticable to polish cellulose enamel in the usual way when applied to fabric.

To prepare the surface of the fabric, it should be washed with petrol or turpentine to remove all trace of polishes, grease, etc. The use of a small nail-brush will materially assist in freeing the grain of the leather from same.

Two coats of fabric enamel are usually sufficient. The first of these must be a light coat, followed 30 minutes later by one full coat.

Colour Mixing

Perhaps one of the most important things in the paint shop to-day is that of colour mixing. This is due to the enormous amount of repair work which requires matching up to the existing colour. Colour matching is a scientific art, and can be brought to perfection only by years of practice and experience. So it is essential that every operator should endeavour to learn something of this art. A natural eye for colour is perhaps the greatest asset of all. Then come the fundamental principles.

Actually there are only three colours, these being red, blue, and yellow, and are known as the primary colours. Black and white are not known as colours but as neutral tints. They are, however, indispensable for mixing and tinting. If any two of the primary colours are mixed together, they will produce another colour ; this is known as a secondary colour; and to take the matter one step farther, if any two of the secondary colours are mixed together, these will produce yet another colour, which is known as a tertiary colour. With this range of colours, known as base colours, it is possible, by varying the quantity, to produce every shade, hue, and tint in the vast range of nature. These base colours are those which should be used for matching, as they will give greater permanency than colours which are obtained by intermixing ordinary standard colour-book shades, because when standard colours are intermixed by what can be termed a " hit-and-miss " method, the result may be that of considerable fading, due to the fact that standard colours have already been made up from the base colours. The proportions, therefore, are unknown to the mixer.

A good range of base colours is as follows :

Prussian Blue
Ultramarine Blue
Dark Chrome Green

Light Chrome Green
Orange Chrome
Lemon Chrome
Ochre
Burnt Sienna
Red Oxide
Crimson Red
Maroon
Deep Red
and
Black and white.

It must always be remembered that colour in its wet form is slightly different from when it is dry. There is no hard and fast rule which can be followed, because some pigments dry lighter and some darker; and furthermore, a matt film of colour will also show a slight difference from one which has been polished. So after a match has been made. it will not show true to colour until the film of cellulose has dried out and been polished. Therefore a slight allowance must be made for this change.



Fig. 8.—THE TRIMMING HAS TO BE PROTECTED FROM THE CELLULOSE SPRAY DUST

Here is an example of how the trimming is masked whilst panels and doors are being cellulosed.
(*By courtesy of the Provincial Sheet Metal Works, Cheam*)

As a guide to mixing any particular shade, the following is a broad outline. Consider the colour to be matched and select the nearest shade obtainable, rather lighter than darker. Next consider the top tone of the shade in question. For example, a green may have a blue tone predominating; or alternatively a yellow cast. It will then be necessary to decide whether that top tone can be introduced to the enamel you have selected, to act as a base colour, by intermixing perhaps another tone which embodies the "tone" necessary.



Fig. 9.—REPLANISHING REAR WING IN POSITION PRIOR TO WELDING



Fig. 10.—WELDING FRACTURE IN REAR WING BY OXY-ACETYLENE PROCESS (*By courtesy of the Provincial Sheet Metal Works, Cheam*)

Some Standard Colours

A number of colours and the method by which they can be produced from the base colours are given below. They are very familiar to the paint shop, as they are the standard colours used by many mass production car manufacturers. It must be made quite clear that if these colours are made to the following formulas, they will not be a dead match to the cars in question. Firstly, because the existing colour has weathered, which naturally alters it, sometimes quite considerably. Reds in particular are prone to this. Secondly, the base colours may vary according to the method of manufacture. For instance, manufacturer "A's" Prussian Blue may not be identical in shade to manufacturer "B's," etc. It must be left to the intelligence of the mixer, coupled with the information which follows, to make a successful match.

Austin Westminster Green

Dark Chrome Green	67 parts
Burnt Sienna	8 ,,
Black	25 ,,

Hillman Aero Blue

White	67 parts
Black	18 ,,
Ochre	8 ,,
Prussian Blue	7 ,,

Morris Green		
	Prussian Blue	52 parts
	Lemon Chrome	26 ,,
	Black	10 ,,
	Orange Chrome	6 ,,
	White	6 ,,
Rover Grey		
	White	83 parts
	Black	13 ,,
	Lemon Chrome	4 ,,
Standard Fawn		
	White	83 parts
	Burnt Sienna	9 ,,
	Black	8 ,,
	Light Chrome Green	Tint only
Ford Vineyard Green		
	Light Chrome Green	50 parts
	Black	34 ,,
	Prussian Blue	16 ,,
	Orange Chrome	Tint only

Refinishing Dashboards and Fillets

The paint shop is often called upon to refinish dashboards and fillets which are, in common with modern practice, made of metal, whereas the finish must represent that of wood. Many of these finishes are obtained by the use of photographic transfers. These transfers are applied in the usual manner and finished with clear lacquer.

The operator can produce this finish in the following manner, bearing in mind that the success of this depends entirely on his skill as a grainer : spray one or two coats of cellulose enamel of a colour which most closely resembles the lighter colour of the desired wood to be copied. When dry, brush over this one coat of water-colour which, in this case, should match the darker shade of the grain. Before this is dry it should be grained in the usual manner of graining. When dry, one or more coats of cellulose clear lacquer should be applied. In explanation : graining is carried out in water-colour because it could not be done satisfactorily in cellulose, and were an oil-colour used, this would give rise to trouble when the clear lacquer is applied in finishing.

Sign-writing in Cellulose

Sign-writing on commercial vehicles which are to be finished in cellulose is sometimes a problem. The following method for cellulose lettering by spray is unequalled when cost is not the most important feature. Prepare the surface in the usual way up to the filler stage. Now spray, on



Fig. 11.—WHEN A WING IS TOO BADLY DAMAGED TO BE REPAIRED ON THE CAR, IT IS REMOVED AND REPAIRED AT THE PANEL-BEATER'S BENCH (*Provincial Sheet Metal Works*)

the area to be occupied by lettering, three coats of cellulose enamel of the shade required for the letters themselves. The sign-writer now writes in the lettering with masking compound. After the writing is completed, overspray the whole surface with three coats of the colour desired for the background. When the last coat is dry, wash the surface with water to remove all traces of the masking compound, thus displaying the writing underneath. This finish, unlike ordinary sign-writing which has been written in oil-colours, can be polished with the rest of the body without fear of its rubbing off. Furthermore it has the look of an enamelled sign.

COMMON TROUBLES, CAUSES AND REMEDIES

Here follow a few of the most common troubles, giving their cause and remedy.

Orange Peel

Surface resembles slightly pebbly effect.

Cause: Too high or too low air pressure. Spraying consistency incorrect.

Remedy: Check air pressure. This should be, as previously remarked in this article, approximately 55 lb. A test for the spraying consistency

can be carried out as follows: thin the material approximately 50–50 with thinners and spray one stroke across a test panel. On examination, should it be found that either edge has a speckly appearance, it is probable that the material is not quite thin enough, because the outer edges should fade away evenly to nothing.

Blushing

This is a white haze over all or a portion of the surface.

Cause. Unsuitable thinner or lacquer sprayed under bad conditions, such as cold, draughts, or humid atmosphere.

Remedy. Do not try to polish out this haze, but overspray with a non-blushing thinner.

Pin-holding or Bubbling

Cause:

(*a*) Use of too rapid-drying thinner.
(*b*) Too rapid surface drying.
(*c*) Air pockets trapped under surface.
(*d*) Moisture coming through air line.

Remedy. Use slower-drying thinner. Avoid draughts. Blow out air line and inspect pressure tank for traces of water.

Bleeding

Bleeding occurs when a pale shade is sprayed over such colours as reds and dye blacks.

Cause. Through the use of various dyes in these colours.

Remedy. To refinish over a bleeding surface spray two coats of lacquer sealer to which has been added aluminium powder in the proportion of ½ lb. powder to 1 gal. sealer. Allow to harden off 2 or 3 hours before applying the new colour.

Body Solder

This is used for the purpose of filling up bad imperfections and frequently gives rise to trouble.

Cause. Principally due to the flux used for tinning the panel, the result usually being that all the cellulose applied over this solder will frequently be found to crack and flake off.

Remedy. Make sure that a suitable flux is used and thoroughly scour the repair with a coarse grade of water-paper before any material is applied.

Polishing

Although polishing is usually carried out by hand, the mechanical rotary polishing machine is favoured by some. It requires experience to use such a machine, and extreme care must be taken, otherwise the

lacquer film can very easily be burnt, due to the heat which is generated by the polishing mop revolving at high speed. The tensile strength of the cellulose film will suffer ; and furthermore, an excess of colour may be removed, leaving the surface shady. A special smoothing compound is necessary, and it should be applied to the part which is being polished and not directly to the polishing mop.

Masking

For protecting glass and plated parts which are not to be coated, and for duotone work, it is necessary to mask off the various parts. For this purpose, the masking can be carried out by the use of either masking paper, adhesive masking tape or masking compound. Masking paper is adhesive on one side, and can be purchased in various widths. It is applied by moistening with water and sticking in position. It should be stripped off when possible whilst the last coat of cellulose enamel is still wet, to ensure clean dividing lines without tearing the film. Masking tape is self-adhesive and can be used repeatedly. Masking compound is in liquid form. It should be brushed freely over the surface to be masked but not flooded. An important point to remember when using this material is that it must be sealed by applying a thin coat of enamel at a reduced air pressure. The reason for this is that if a full coat were applied at the usual air pressure, it would most probably penetrate the masking compound and so prevent its easy removal. It will be found that if the compound is used correctly, it can easily be removed after the enamel coats are dry by sponging with clear water.

In conclusion, it is hoped that this short article will prove of assistance to those employed in the cellulose refinishing business.

LUVAX BIJUR CHASSIS LUBRICATION

By DOUGLAS PERCIVAL

THERE is now an increasing demand from the motoring public for automatic chassis lubrication, this being no doubt largely due to the trend of modern coachwork design, which tends to make the various lubrication points more and more inaccessible. As a result, a greater number of car manufacturers are now including an automatic system in the standard equipment of their various models, and it is a method which, without doubt, will become more generally adopted as time goes on.

The function of a chassis lubrication system is to supply a measured quantity of oil to the various chassis bearings in accordance with their respective requirements. The bearings lubricated are usually front-axle

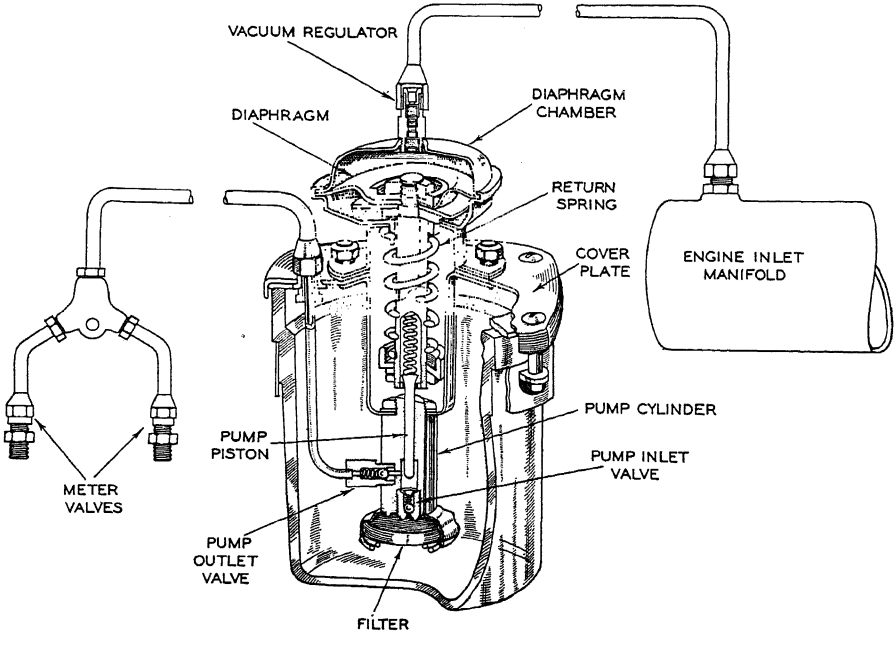


Fig. 1.—PUMP UNIT AND OIL RESERVOIR OF LUVAX BIJUR VACUUM-OPERATED CHASSIS LUBRICATION SYSTEM

swivel pins, steering-ball pins, spring shackles, and brake shafts, etc., in fact, all bearings requiring lubrication with the exception of those that rotate, such as the wheel hubs and universal joint.

Three Types

The Luvax Bijur system is made in three types, namely :

(1) The vacuum-operated automatic system.
(2) The thermal automatic system.
(3) The manually operated system.

Each of these systems comprises an oil reservoir, a pumping unit, and a system of piping to distribute oil to the various bearings, where meter valves are located, which control the amount of oil passed, so that each bearing receives the correct quantity of lubricant.

THE VACUUM-OPERATED SYSTEM

We will deal first with the vacuum-operated system. The pump unit is mounted inside the oil reservoir, these two parts forming a complete self-contained unit, as shown in Fig. 1. It is usually mounted on the engine side of the dash. On top of the pump unit is a diaphragm chamber in which is located a diaphragm, to which is attached the pump plunger. A spring is incorporated which exerts a downward pressure on the diaphragm and plunger. Screwed into the top of the diaphragm chamber is a vacuum regulator valve, and from this is taken a pipe to the engine intake manifold. The operation is as follows :

Operation of the Vacuum-operated System

When the engine is started up and running at idling speed, the vacuum in the inlet manifold is of a high order, and consequently the pump diaphragm is drawn up towards the top of its stroke. When the engine is accelerated, the vacuum decreases, and the spring in the pump unit returns the diaphragm towards the bottom of its stroke. When the engine is running at medium speed, the vacuum is of a sufficient value to hold the diaphragm midway between the top and bottom of its stroke. Movement of the throttle causes a variation of vacuum in the inlet manifold, and this in turn causes an upward or downward movement of the diaphragm, which being connected directly to the pump piston causes pumping.

In ordinary road driving, there occurs an almost continuous change of vacuum in the engine intake manifold, due to throttle changes. Actually, it is like a wave, having its peaks and hollows a little above and a little below an average value. These waves occur rather slowly and the diaphragm ordinarily follows them closely. However, in conditions of heavy traffic, when there are more violent accelerations and decelerations, the changes of manifold vacuum occur more frequently and are of greater magnitude. In order to limit their action on the diaphragm and reduce

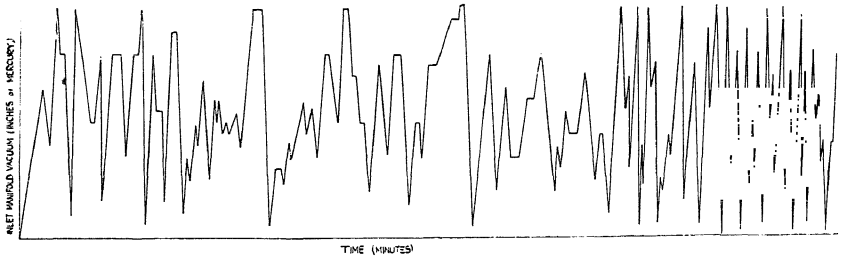


Fig. 2.—DIAGRAM SHOWING VACUUM CHANGES IN INLET MANIFOLD



Fig. 3.—DIAGRAM SHOWING CORRESPONDING VACUUM CHANGES IN PUMP DIAPHRAGM CHAMBER WITH RATE TR2 VACUUM REGULATOR

their effect to approximately the same as that obtained under average road conditions, the vacuum regulator is fitted between the diaphragm chamber and the manifold.

The Vacuum Regulator

In the vacuum regulator is a small accurately sized restriction orifice, the area of which is arranged to permit a comparatively slow flow of air—thus frequent large-magnitude vacuum fluctuations in the manifold do not have a full effect on the pump diaphragm. This is illustrated clearly in Figs. 2 and 3. Fig. 2 is a diagram of the vacuum fluctuations in the manifold of a typical six-cylinder car whilst being driven along a road on the outskirts of a town, and the effect of driving through a section of heavy traffic which was met with is seen at the right-hand end of the diagram. Fig. 3 shows the vacuum variation in the pump diaphragm chamber and clearly illustrates the effect of the vacuum regulator. It will be observed that the " peaks " and " hollows " due to the traffic section in Fig. 2 have been damped out—the results being that the pump output is consistent within reasonable limits during both open-road and traffic conditions.

From the foregoing it will be seen that the vacuum regulator is a very

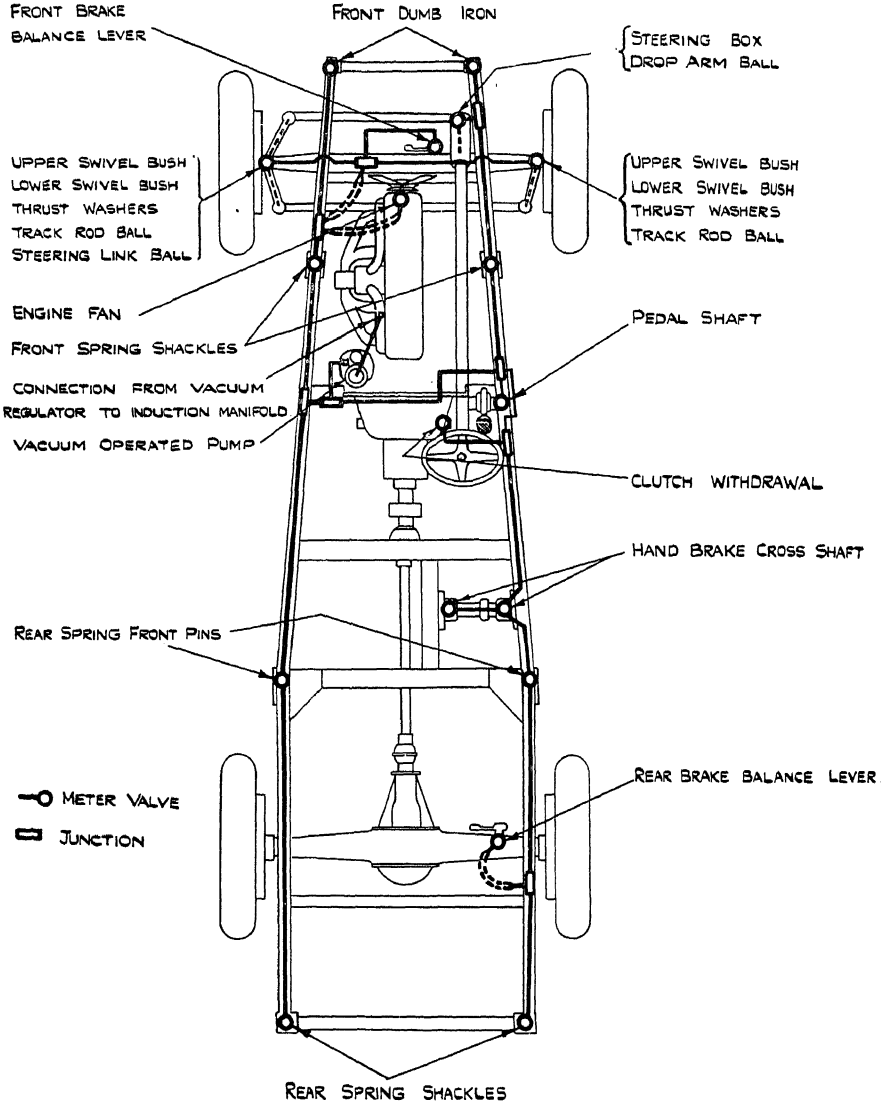


Fig. 4.—DIAGRAM OF TYPICAL LAYOUT OF VACUUM-OPERATED LUVAX BIJUR CHASSIS LUBRICATION SYSTEM

This shows the pump and reservoir unit mounted on the engine side of the dashboard, and a flexible connection between the vacuum regulator and the engine inlet manifold—usually termed the " vacuum " connection. A small brass or copper pipe is used for the oil pipe line, and is shown running from the pump outlet to a junction on the dash and from thence to the offside and the nearside of the chassis.

important part of the pump unit, and a moment's thought will show that the size of its restriction orifice controls the pump output. The vacuum regulators are therefore made in different sizes or " rates," so that the pump output may be arranged to suit the requirements of the car to which it is to be fitted. The " rate " number is stamped on each regulator, and it is important, when fitting a replacement, to ensure the same " rate " being used as that originally fitted.

Further remarks concerning the vacuum regulator are included under " maintenance "—and these should be noted carefully.

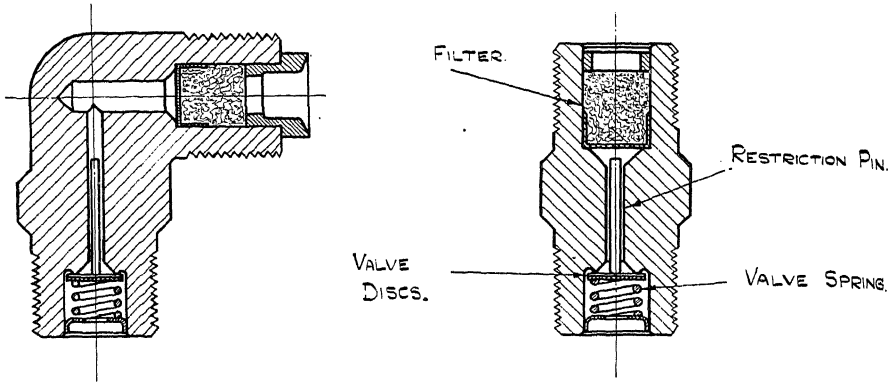
The Meter Valves

The oil is delivered from the pump outlet, through a system of piping to meter valves located at each chassis bearing. In each meter valve is an accurate restriction orifice, which controls the flow of oil to the bearing, and also a valve which prevents oil draining away from the system whilst the car is at rest. The meter valves are made with restriction orifice areas, of different sizes, so that various rates of flow are obtained and thus the requirements of both large and small bearings may be catered for satisfactorily irrespective of the fit of the shaft in the bush. Each meter valve is stamped with its rate number.

A Typical Layout of Vacuum-operated System

A diagram of a typical layout is shown in Fig. 4. This shows the pump and reservoir unit mounted on the engine side of the dashboard, and a flexible connection between the vacuum regulator and the engine inlet manifold ; this is usually termed the " vacuum " connection. For the oil pipe line a small brass or copper pipe is used and is shown running from the pump outlet to a junction on the dash and from thence to the offside and the nearside of the chassis, branching on each side to the front and rear dumb irons. The meter valves at the various bearings are connected directly to the main pipe line by " T " heads or by branch lines, such as shown for the clutch-withdrawal bearing. Flexible connections are used between the frame and the axles.

Briefly, then, the operation of the system is as follows : whilst the car is running, the pump delivers a slow, continuous feed of oil through the pipe line to the meter valves situated at the various bearings. The vacuum regulator controls the amount of oil delivered by the pump, and the volume delivered is proportioned out to the various bearings in the correct ratio by the meter valves. A low-rate meter valve at, say, the brake cross-shaft ensures that only the small amount of lubricant necessary is delivered, whilst a higher-rated meter valve at, say, the front-axle king pin, ensures an adequate supply. The complete system is always solidly full of oil, so that immediately the pump starts working, delivery commences through the bearings.



Elbow type meter valve — Straight type meter valve

Fig. 5.—CONSTRUCTION OF METER VALVES

Construction of the Vacuum-operated System

The combined reservoir and pump unit used with the vacuum-operated system is of a simple construction. The reservoir, which is carried in a steel mounting bracket, is made of glass, so that the oil level may readily be seen. The cover plate is held in position by four bolts attached to lugs on the mounting bracket. A cork gasket is used to make a joint between the glass and the metal cover plate.

The Pump Unit

The pump unit, which is carried on the cover plate, comprises a long piston of small diameter, which affords a tight oil seal without packing. The pump is provided with self-contained inlet and outlet valves, in each of which a ball is pressed against a conical seat by a small spring. From the outlet valve, at the side of the pump cylinder, a pipe leads to the outlet connection mounted on the cover plate. Oil is admitted to the inlet valve in the bottom of the pump cylinder through a removable felt filter, backed by a fine-mesh brass gauze.

The pump cylinder is bolted to a " U " strap, depending from the cover plate, and these parts are permanently secured together, forming a sub-assembly.

The pump piston and its actuating diaphragm, together with the diaphragm chamber, constitute a sub-assembly also. The upper end of the piston is provided with a universal joint to connect it to the diaphragm shaft, which in turn is bolted to the underside of the diaphragm. The latter is urged downward against a limiting stop by a large-diameter coil spring. The outer periphery of the diaphragm is secured between the upper and lower halves of the diaphragm chamber. As already mentioned, in the upper half of the latter is screwed the vacuum regulator, which is connected by a length of pipe to the engine inlet manifold.

The vacuum regulator comprises a body screwed at each end, two felt and brass gauze filters, a baffle disc, a dust-trap cup, and a restriction cup, the whole forming a self-contained unit.

The Oil Pipe Line

Soft brass or copper tubing of $\frac{5}{32}$-in. outside diameter is used for the oil pipe line, and $\frac{3}{16}$-in. outside diameter is used for the vacuum line. All connections are made with screwed joints, no soldering being used anywhere in the system.

The connection of the pipe line to the junction-pieces and meter valves is made with compression sleeves (or olives), which are permanently pinched on to the end of the tube as the nut is tightened up.

The construction of the meter valves is shown in Fig. 5. Each meter valve comprises a body threaded externally at each end and drilled in the centre with an accurately sized restriction hole. In the body is fitted, first, a felt and gauze filter to protect the restriction orifice from any dirt, chips, or copper oxide as might originally be in the pipe line; secondly, an accurately sized restriction pin, positioned in the restriction hole, so that the clearance between the two forms an accurately sized aperature. In all the meter valves, the hole in the body is the same size, but the restriction pins are of different diameters, thus affording different restrictions and consequently different rates of flow. Finally, comes a valve, which in some types consists of a floating disc and in others of a lightly spring-loaded disc. The purpose of the valve is to prevent oil draining away when the system is not working.

MAINTENANCE AND SERVICE REPAIRS OF VACUUM-OPERATION SYSTEM MAINTENANCE

The normal maintenance required is as follows:

(1) Inspect the oil level in the reservoir and replenish if necessary with Luvax Chassis Oil or an alternative approved by the manufacturer of the car to which the system is fitted. The choice of oil is important; it must be of the correct viscosity, anti-corrosive, and free from gumming tendency, therefore do not use any other than Luvax Bijur Chassis Oil or an approved alternative. A filler cap is provided on the coverplate. The reservoir holds approximately $1\frac{1}{3}$ pints. The oil level should not be allowed to fall lower than $\frac{3}{4}$ in. from the bottom. When replenishing, do not fill above the upper edge of the mounting bracket. The oil consumption, of course, depends upon the number of bearings being lubricated. A system comprising sixteen meter valves, uses approximately 1 pint of oil per 1,500 to 2,000 miles.

(2) The vacuum regulator should be replaced by a new one every 10,000 miles. This is because dirt and dust, which are drawn in with the air, tend to choke the filter elements, causing the action of the pump to be restricted. Replacement vacuum regulators are obtainable from the

makers. Make sure that the replacement is of the same " rate " as the original one. The " rate number " is stamped on each and should be quoted when ordering. When fitting the new one, it is advisable to first screw the regulator in until one complete thread is holding ; then add a drop of white-lead paint, hermetite, or some such jointing material to the remaining threads before screwing the regulator completely home. This will prevent air leak at the thread.

(3) An occasional glance should be given to such remote points as the front and rear dumb irons, or the steering-ball pins. If the system is working correctly, oil will be visible at these points—a slight wetness should be seen. If they appear dry, the system should be examined. Instructions for this are given below under " Service Repairs."

" Service Repairs " (for the vacuum system)—All Chassis Bearings Dry

Let us first of all assume that the system on a car is being examined and it is found that all the bearings are dry. This may be due to the pump unit not working or to an uncoupled or faulty pipe connection, or broken pipe which allows the oil delivered by the pump to take the path of least resistance and to fall on to the ground, i.e. to pass out of the open-minded pipe.

The latter possibility may be readily checked by a visual inspection of the pipe line. A leakage is very noticeable ; it is well known that a little oil makes a lot of " mess." The remedy is to repair the leakage and prime the system.

After any failure or repair involving a leakage from the pipe line, the system should be primed, as for efficient working it must be solidly full of air-free oil. The pipe line should be disconnected at the pump outlet and the priming gun attached to the end of the pipe. Force oil through until air-free oil is reaching each bearing. The makers supply a " priming gun " complete with a convenient flexible connection for this purpose. On some cars a priming nipple is incorporated in the junction on the engine side of the dashboard. This provides a convenient point for attaching the priming gun, and avoids having to disconnect the pipe at the pump outlet. If no priming gun is available, the system may be primed by operating the pump unit by hand. To do this, first remove the two nuts and lock washers at the base of the diaphragm chamber. The pump can then be operated by alternately raising and lowering the diaphragm unit about $\frac{3}{4}$ in.—this will force oil out of the pump outlet into the pipe line. This method is slower than using a separate priming gun, but can be carried out effectively in approximately 15 minutes. The outflow from the pump is very small, as the flow required to correctly lubricate sixteen points on a chassis is only 1 cu. in. per 100 miles.

Checking the Pump Unit

To check the pump unit and locate trouble, if any, proceed as follows : first of all, make sure that the vacuum regulator is functioning correctly.

See that the diaphragm and pump piston respond to vacuum fluctuations. To do this, start the engine and disconnect the vacuum line at the vacuum regulator. By holding the vacuum tube tightly against the vacuum regulator, the piston should be drawn up to the top of its stroke. By removing the vacuum tube from the regulator, the piston should return to the bottom of its stroke in 5 seconds or less. If the piston does not move as described, the vacuum regulator should be replaced by a new one of the same "rate." If fitting a new regulator does not have the desired effect, it indicates either a faulty diaphragm or piston, and a replacement "diaphragm and piston assembly complete" should be obtained from the makers.

If, however, the vacuum regulator and diaphragm are found to be correct, the next step is to see that movement of the pump piston causes delivery of oil. This is easily checked, by disconnecting the chassis oil line at the pump outlet and removing the two nuts and lock washers at the base of the diaphragm chamber. Then operate the pump by alternately raising and lowering the diaphragm unit about $\frac{3}{4}$ in. On the down strokes, one or two drops of clear oil, free from air, should be discharged at the outlet. During the upward movement, oil should not be sucked back down the outlet hole. Also, when a finger is held over the oil-outlet hole, there should be a distinct sign of pressure during the down stroke.

Clogged Filter

If the above test reveals faulty operation, it may be caused by the filter having become clogged up, due to the use of unsuitable or dirty oil. To examine the filter, remove the four screws, holding the cover plate and pump assembly to the mounting bracket; the complete assembly can then be withdrawn. If the filter is found to be dirty, it can be readily taken out by removing the spring-retaining ring. It can then be washed in paraffin or petrol, until clean and white. Should the results still be unsatisfactory, the complete unit should be returned to the makers for repair or replacement, as special tools and fixtures are required for a complete dismantle and reassembly.

Fitting New Glass Reservoir

To fit a new glass reservoir, should the original one have been broken, disconnect the vacuum line and the oil line at the pump outlet. Then remove the four screws holding the cover plate to the mounting bracket. The cover plate may then be lifted off and a new reservoir dropped into place in the mounting bracket. The bottom of the reservoir is flat, so that it will stand upright when dismounted from the car.

Two further points in connection with the pump unit should be noted. Special care should be taken when reassembling the diaphragm and pump assembly to make sure that the piston enters the cylinder correctly and there is no excessive friction, caused by dirt or burrs. Secondly, the round

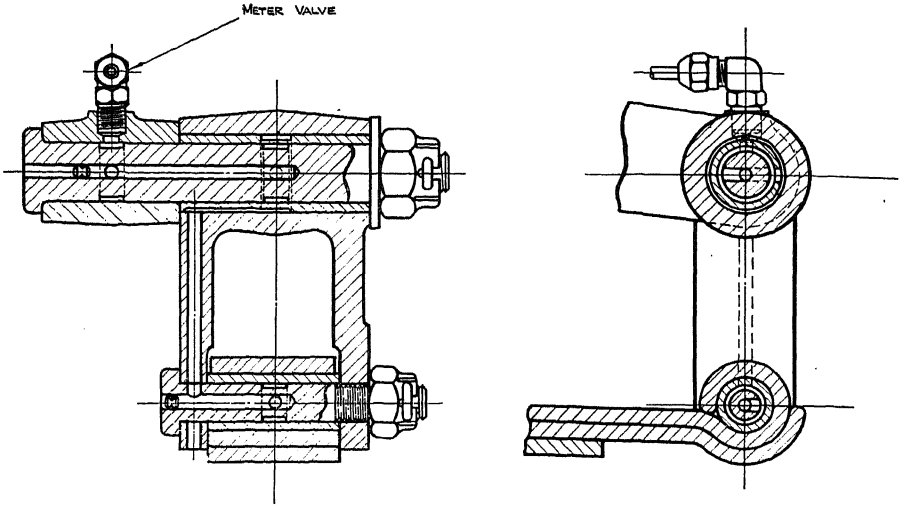


Fig. 6.—TYPICAL REAR-SPRING SHACKLE
Showing method of lubrication.

nut on the pump shaft is set at the factory to give the correct loading on the spring, and is secured in place by staking the pump shaft, through a hole in the nut. If the pump has been tampered with and the nut turned, the entire assembly should be returned to the makers for resetting, as to get the best results it is necessary for this to be done with a specified vacuum in the diaphragm chamber.

Finally, should the above tests show the pump unit to be working correctly and yet when connected up and the car engine is accelerated and decelerated no oil is delivered, then the vacuum line and connections should be examined. It is imperative that these are airtight.

All Bearings Insufficiently or Excessively Lubricated

We have now considered the correct action in dealing with a car on which all the chassis bearings are dry. Let us now take a car on which all the bearings are receiving oil but the supply is insufficient, or alternatively, all the bearings are receiving an excessive supply.

In both of these instances, the output of the pump would appear to be unsuitable, being too low in the former case and too high in the latter. The pump output may be varied by fitting a higher- or lower-rated vacuum regulator as required. They are made in four rates, i.e. TR1, TR1½, TR2, and TR3. However, before changing the rate of the vacuum regulator, careful inquiry should be made to ascertain if the insufficient or excessive supply, as the case may be, has been occasioned during normal usage. For instance, the appearance of an insufficient supply may be due

to the car having been run with the reservoir empty, prior to the inspection ; or again—is the excessive wetness due to the system having been hand-primed a week or so previously ?

A Number of Dry Bearings (fed by different Meter Valves)

If a portion of the system is found to be dry it is probably caused by a stoppage in the pipe line which feeds that portion. As an example, let us assume that the system shown in the diagram (Fig. 4) has the following dry bearings on the offside : Hand-brake cross-shaft, rear-spring anchor pins, rear brake balance-lever, and rear-spring shackle. A study of the diagram will show that a stoppage has occurred in the length of pipe between the junction which connects to the clutch withdrawal, and the hand-brake cross-shaft, oil having reached the former but not the latter. The length of pipe between these two points should be removed and cleaned or a new piece of pipe fitted and the system primed. A stoppage in the pipe line rarely occurs, but when it does it is more often due to the pipe having been flattened by a blow or a pinch than to foreign matter in the pipe.

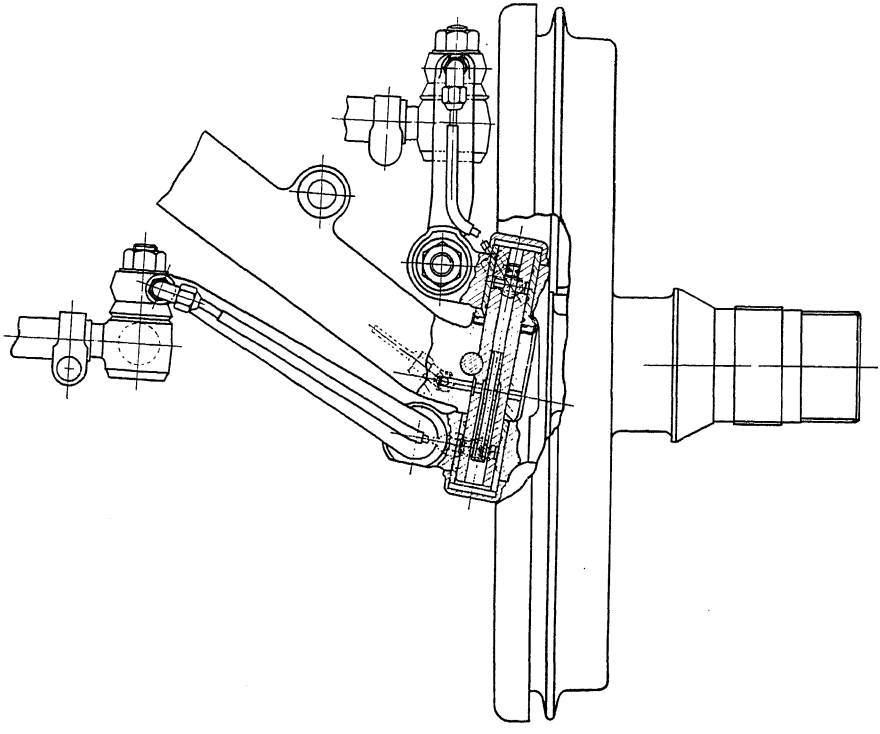


Fig. 7.—TYPICAL FRONT-AXLE INSTALLATION WITH LUVAX BIJUR LUBRICATION

One Bearing receiving an Excess of Oil (or a Group of Bearings fed from One Meter Valve)

If only one bearing is found to be receiving an excess, or a group of bearings fed from one meter valve, the latter should be changed. The feed to the bearing may be varied by fitting a higher- or lower-rated meter valve as required; they are made in eight different rates, i.e. 00, 0, 1, 2, 3, 4, 5, and 6. In a case such as this, however, it is advisable to first fit a new valve of the same rate number, as the original one may have been incorrectly calibrated. The excess oil should then be wiped from the bearing and the performance watched for the next hundred miles or so. If the supply is still excessive a lower-rated one may be fitted.

Only One Dry Bearing (or a Group of Bearings fed from One Meter Valve)

Should it be found that only one bearing is dry, or a group of bearings fed from one meter valve, it indicates either a fault in the meter valve, or (if the meter valve is situated at a terminal point of the system, such as the rear shackles or brake cross-shaft, as in Fig. 4) a stoppage in the pipe line.

A check should be made by disconnecting the pipe line at the point where it is connected to the meter valve. If oil is not present in the end of the pipe, trace the pipe along to the next connection, and disconnect and examine; repeat this until the stoppage is traced. A flattened pipe, caused by a blow or pinch, may be the source of trouble, in which case a new length of pipe should be fitted and the system primed.

If it is found that oil has reached the end of the pipe, adjacent to the meter valve, the latter should be unscrewed from the bearing and examined. If the outlet end of the meter valve is dry, it indicates a stoppage, and a new valve of the same rate should be fitted.

When fitting a new meter valve, either at the end of a line, or a T-head —inserted in the line—care must be taken to assemble the filter end of the meter valve towards the pump, so that the flow of oil has to pass through the filter before reaching the restriction orifice. The filter end of the meter valve can be distinguished as the felt is discernible through the end of the body.

Instances may be met with where oil is found to be emerging from the outlet end of a meter valve and yet it does not reach the actual bearing surface; this may be due to the internal oil ways in the bearing parts having been incorrectly drilled, left undrilled, or choked up. The effect of either of these faults will be readily appreciated by a study of Fig. 6 and Fig. 7.

Lubrication of Typical Rear-spring Shackle

Fig. 6 shows a typical rear-spring shackle. It will be seen that the meter valve is screwed into a hole in the bracket which communicates with an annular groove around the pin. The oil passes around this groove and

through a radial hole in the pin to a longitudinal hole in the centre, through which it passes to the upper bearing. Part of the oil spreads along the bearing surface and part passes out through a radial hole in the bush to grooves formed in the outside of the bush. These grooves communicate with a hole drilled in the shackle link, down which the oil flows to the lower pin in which holes and a groove are formed, to pass it to the surface of the lower bearing.

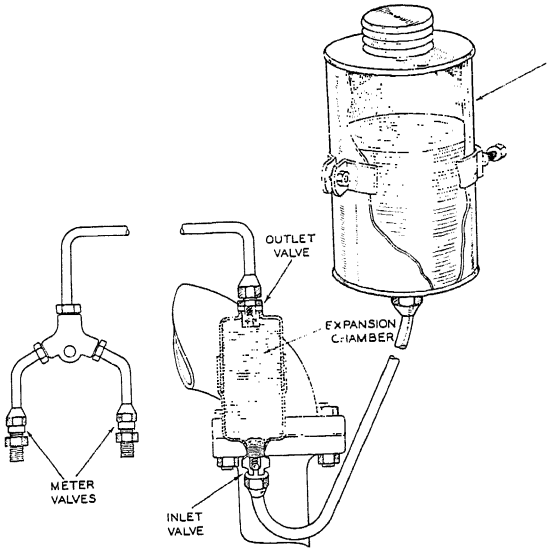


Fig. 8.—THE LUVAX BIJUR THERMAL SYSTEM

It will be obvious that if either of the oil holes or grooves are choked up or left undrilled, or if the parts are incorrectly assembled so that the holes and grooves do not connect up, oil will not reach the bearing surfaces as intended, although it may be reaching the outlet end of the meter valve.

Typical Front-axle Installation

Fig. 7 shows a typical front-axle installation. With this arrangement the oil is carried from the frame via a flexible connection to the axle beam. A pipe is run along to each end of the beam, where a meter valve is positioned. The meter valve discharges the oil through a hole in the end of the beam and the king-pin to the centre of the pin. In the centre of the pin a standpipe is fitted. The oil rises up the annulus around the outside of the standpipe, and part flows through a radial hole in the pin to lubricate the upper bush. A hole is also provided which communicates with a pipe running down the steering arm to the ball pin. It will be noted that a slot is formed in the upper end of the standpipe ; this is to ensure that the correct proportion of oil flows down the centre of the standpipe to the lower end of the king-pin, whence it is carried via suitable oilways to lubricate the thrust, bearing, lower bush, and track-rod ball. In this instance one meter valve feeds a number of bearings, and it will be apparent that if the oil ways are not correct the oil will not reach the desired places.

The shackle and axle arrangements shown in Figs. 6 and 7 are typical

examples only. Actually there are many variations, according to the design requirements of the various cars.

THE LUVAX BIJUR THERMAL SYSTEM

Description

This system is illustrated in Fig. 8. The pumping action is caused by heat from the engine. The system comprises an oil reservoir, usually mounted on the engine side of the dashboard, which supplies oil to an expansion chamber, in the form of a closed cylinder, with inlet and outlet valves, mounted adjacent to the exhaust manifold. Oil is fed from the expansion chamber to distributing pipes and meter valves identical to those used with the Luvax Bijur Vacuum System—already described.

Operation of the Thermal System

When the system is initially fitted, it is primed and the reservoir filled so that all pipes and the expansion chamber are solidly full of oil.

When the engine is started, the oil in the expansion chamber heats up and expands (due to the expansion chamber being in close contact with the exhaust manifold) and oil is forced through the outlet valve to the distributing lines and meter valves. When the temperature drops, the oil in the expansion chamber contracts and a replenishment charge is automatically drawn through the inlet valve from the reservoir. This cycle occurs with every rise and fall of temperature in the expansion chamber.

Changes in engine temperature, and therefore of the temperature in the expansion chamber, due to variation in running conditions, such as between flat roads and hill climbing, or slow and high speeds, will produce a delivery of oil. Most of the flow, however, takes place with the initial temperature rise at starting. The starting temperature under the bonnet, of course, varies approximately as the outside temperature, but the running temperature varies only a little. Therefore, the oil delivery will be slightly less in hot weather when the starting temperature is high, than in cold weather when the starting temperature is low. However, the variation in England is only small, and in practice it is not found necessary to make any adjustment for summer or winter. If required, on cars operating constantly under extreme conditions, such as met with in, say, Canada or India, an adjustment can easily be made by moving the expansion chamber closer to or away from the source of heat, i.e. the exhaust manifold. The clip which secures the chamber to the manifold is usually of such a construction that it can be easily modified to make this adjustment.

Construction of the Thermal System

The construction is simple and can be described in a few words—in fact, the illustration in Fig. 8 is practically self-explanatory.

The reservoir is of either glass or metal. It holds a little over 1 pint. The filler cap is on the top and an outlet connection at the bottom. There is no valve in the outlet—it is merely a "straight-through" nipple. A pipe is taken from the reservoir outlet to the expansion-chamber inlet valve. The expansion chamber is made of steel. The outlet valve is screwed into the top and the inlet into the bottom. They are clearly stamped "out" and "in" respectively, to distinguish them. The valves consist of a brass body, screwed externally at both ends; inside is a ball held on to a seat by a light spring. A pipe is taken from the outlet valve to the chassis distribution system; the latter is the same as that used in the vacuum system already described.

MAINTENANCE AND SERVICE OF THE THERMAL SYSTEM

Maintenance

Replenish the reservoir when necessary with Luvax Bijur Chassis Oil or an alternative approved by the makers, or by the manufacturers of the car to which the system is fitted.

Do not allow the reservoir to become empty. If, however, this has inadvertently occurred, it is advisable, when refilling, to prime the system. Although, given time, it will automatically prime itself, it may take several hundred miles' running to do this. When priming, unscrew the connection at the base of the reservoir, and attach the priming pump to the end of the pipe; this ensures that the feed pipe from reservoir to expansion chamber, the expansion chamber, and the distribution lines will all be primed. Force oil through until it is exuding from each bearing.

Give an occasional glance at the chassis bearings and see if oil is reaching them—a slight wetness should be visible externally. If the system does not appear to be delivering oil correctly, proceed as described below under "Service."

Service Repairs for the Thermal System

If all the bearings are dry, indicating that oil is not being delivered from the expansion chamber, examine the pipe and joints between the reservoir outlet and the expansion-chamber inlet valve. It is imperative that this connection is airtight, otherwise, when the oil in the expansion chamber contracts, air will be drawn in, instead of oil, from the reservoir.

Should it be found that the trouble was not caused by an air leak in the supply line, remove the inlet and outlet valves and see that they are not choked up. If necessary, flush them through with paraffin.

To test the outlet valve to see that it holds pressure correctly, grip it in a vice, and apply the nozzle of an oil-gun to the end to which the pipe attaches. If the ball is seating correctly, it will not be possible to force oil through.

A convenient method of testing the inlet valve is to hold the expansion chamber in a vice, with the inlet valve screwed into position, but the out-

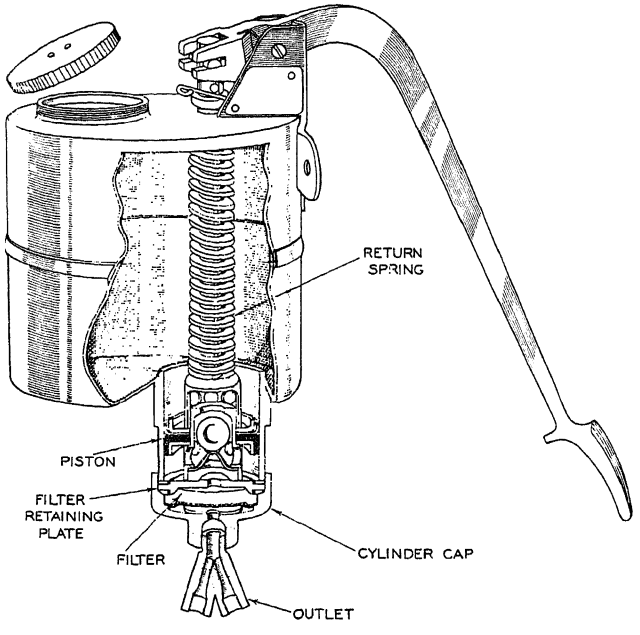


Fig. 9.—COMBINED RESERVOIR AND PUMP UNIT OF LUVAX BIJUR MANUALLY-OPERATED CHASSIS LUBRICATION SYSTEM

let valve removed. Insert the nozzle of an oil-gun into the hole from which the outlet valve has been removed, and force oil under pressure into the chamber. If the ball in the inlet valve is seating correctly, it will hold the pressure and prevent oil from exuding.

If either of the valves is faulty, a replacement should be obtained from the makers.

When refitting the valves to the expansion chamber, remember an air-tight joint must be made. It will be found advantageous to screw-in each valve, until one complete thread is holding, then add a drop of Hermetite, or some such jointing material, to the remaining threads before screwing the valve home. Make sure that when assembled into position on the car: the outlet valve is on the top and the inlet at the bottom.

After any attention which has necessitated disconnecting the system, it is advisable, on reconnecting, to " prime " as already described under " Maintenance."

As the meter valves and connection fittings are similar to those used with the vacuum system, the same service instructions are applicable.

THE LUVAX BIJUR MANUALLY-OPERATED SYSTEM

Description

The manually-operated system is similar to the vacuum-operated, with the exception that the pump unit is operated by a foot pedal.

The reservoir and pump form a combined unit, which is usually mounted on the engine side of the dashboard with the operating pedal protruding through at a convenient position for the driver's foot. A depression of the pump pedal causes about an egg-cupful of oil to be discharged under pressure into the pipe line. The number of pump-pedal

operations necessary to maintain the chassis bearings in good condition depends, of course, upon the number of bearings which the system is lubricating. On the average installation one " shot " every 100 miles is satisfactory.

Construction and Operation of the Manually-operated System

The combined reservoir and pump unit is shown at Fig. 9. The pedal is mounted on a fulcrum pin. When the pedal is depressed it raises the piston in the cylinder and at the same time compresses the return spring. Whilst the piston is being raised, oil is drawn through a ball valve, in its centre, to the underside. When the driver's foot is removed from the pedal, the return spring forces the piston downwards. The pressure on the oil below the piston closes the ball valve, thus preventing return flow through the piston, the oil consequently being forced downwards through the filter and out of the pump outlet. The spring is of considerable length, and is so rated that the pressure is practically constant throughout the stroke. The time period during which the piston descends, depends upon the thickness of the oil. On a cold day it takes a little longer than on a hot day ; the amount of oil delivered, however, is the same under all conditions, it merely means that the period of discharge is longer at low temperature. The average time taken is 5 minutes.

Owing to the slow flow, the filter can be sufficiently dense to remove even the smallest particles of dirt without restricting the flow. When the piston reaches the end of its stroke, it effectively closes the hole in the filter-retaining plate so that oil cannot leak away whilst the pump is not being operated.

MAINTENANCE AND SERVICE OF THE MANUALLY OPERATED SYSTEM

Maintenance

Replenish the reservoir when required with Luvax Bijur Chassis Oil or an alternative approved by the makers or by the manufacturers of the car to which the system is fitted. Do not allow the reservoir to become empty.

Operate the pedal every 100 miles or as often as recommended by the car manufacturer. After pressing down the pedal, release it suddenly by removing the foot smartly.

If after depressing the pedal it returns rapidly to its normal position, i.e. in less than 1 minute, it indicates that either the reservoir is empty or there is a fault in the system. If the reservoir is empty, refill it, then operate the pedal until it takes the usual time to return to the normal position. If the quick return of the pedal is not due to an empty reservoir, proceed as per instructions given below under " Service."

Service of Manually Operated System

Here are some of the faults which may have to be dealt with, and their remedies :

All Chassis Bearings Dry

This may be due to the user having neglected to operate the pump pedal or to the reservoir being empty. Ascertain that the reservoir contains oil, and then operate the pedal two or three times and see if oil appears at the various bearings. If with a full reservoir the pedal returns rapidly to the normal position, after being pressed down, it indicates an uncoupled or leaky connection or a broken pipe or alternatively a faulty pump unit. The former may be easily spotted if the pedal is operated four or five times, as all the oil discharged by the pump will be forced out of the broken or leaky connection on to the floor and a pool will form. The pump unit may be tested as follows : if found faulty fit a new one ; do not attempt to dismantle the old one, as special tools are required and must be used, otherwise damage will result.

Testing the Pump Unit

Disconnect the chassis oil line from the pump outlets. Then close the outlets by screwing in solid plugs or by connecting short pieces of pipe with the outer ends hammered flat. The pedal should now be pressed down. With the outlets plugged as described, the piston should hold the pressure ; if, therefore, the pedal shows a visible upwards motion during a period of 2 minutes it indicates a leak past the piston, either past the cup leathers or through the ball valve. Too thin an oil in the reservoir will give this effect, therefore examine the oil and if necessary replace with the correct grade. If the oil is found to be correct, then the fault lies in the pump and a new one should be fitted.

A case may be met with, occasionally, where the pump lever fails to return to its normal position after being pressed down. This may be due to the filter having become clogged, caused by the use of dirty or improper oil. To clean the filter, proceed as follows : Disconnect the chassis oil line at the pump outlets. Then depress the pump pedal and block it in a partially depressed position, with a piece of wood wedged against the instrument board or some such means. Unscrew the cylinder cap on the underside of the reservoir, but take care to have a tin handy, to catch the oil which will run out. Note the position in the cylinder cap of the filter-retaining plate, with its gaskets, before dismantling. Then lift these out, exposing the felt filter disc, which should be removed and washed in petrol until clean and white. There will be found beneath the felt disc in the cap a wire gauze disc. This should be left in position with the ridges against the cap. When reassembling, replace the felt disc and then the filter-retaining plate and gaskets, with the hollow side of the plate facing the felt disc. Be sure that both the gaskets are in the correct position. The cap assembly is now ready to be replaced on the cylinder.

Faults in the junction-pieces and meter valves may be remedied, as already described for the vacuum system. After reconnecting the system, it should be primed until oil is exuding from each bearing.

SERVICE AND REPAIR NOTES ON GILFORD "HERA" 32/29 PASSENGER VEHICLES

The Front and Rear Axles, Steering, and Brakes

By S. E. SMITH

FRONT AXLE

THE front-axle unit fitted to the Gilford "Hera" chassis is of orthodox design and incorporates, as necessary for heavy passenger vehicles, very efficient front-wheel brakes. The brake shoes have large-diameter linings 3 in. wide, which provide ample friction surface, and if the brakes are kept properly adjusted very little attention will be found necessary as regards the brake mechanism.

The swivel or stub axles have parallel pins running in bronze bushes and Timken bearings, and these should be kept very carefully lubricated and periodically checked for wear. The Timken bearing at the top of the swivel pin should be

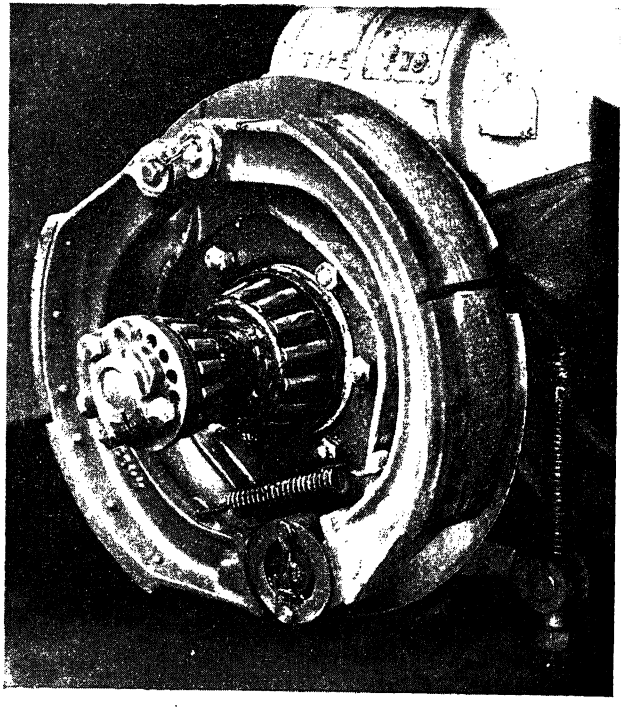


Fig. 1.—THE ASSEMBLY OF THE FRONT HUB BEARINGS, LOCKING WASHERS, AND NUTS

frequently examined, and adjusted as required to take up any slackness which may be present.

To-day the public-service vehicle examiners and certifying officers responsible for the proper mechanical fitness of all public-service vehicles are particularly alert for any wear or defects as regards the front axle. This, of course, can be readily understood, when the important functioning of this unit, particularly in relation to the steering, is considered.

In the circumstances it cannot be emphasised too strongly how essential it is to maintain in first-class manner the front axle and its subsidiary parts.

Overhauling Front Axle

When it becomes apparent by the " play " in the front wheels that new stub-axle pins and bushes are essential, it is strongly advisable to remove the whole front-axle unit complete from the chassis. The procedure to be carried out should be as follows :

Disconnect and remove the steering drop arm from steering arm, also disconnect the servo pipes from the two servo units situated at each end of the axle. Remove next the front-spring shackle bolts, and the front axle will then be free and can be wheeled away from the chassis.

Dismantling

The order of dismantling is to first remove the wheels and hub caps. The special hub nut at each end will then be exposed ; but before these can be taken off it will be necessary to remove the split-pin, special locking bolts, and grub-screws, all of which are additional security in preventing any risk of the hub nut working loose under working conditions and perhaps allowing the wheel to come off, which would be a serious matter with any class of vehicle. After removing the hub nuts, next take off the special " D " washer, when the hub can be removed, together with the steel washers and oil-retaining felts.

The brake shoes come next in dismantling. Undo the two small bolts and plates fitted over the heels of the brake-shoe pivot pins, when the brake shoes can be slipped off.

Now undo the $\frac{1}{2}$-in. bolts which secure the brake-shoe dust shields, and take these off. Then remove the two servo units, when the stub pins and locknuts are exposed for attention. Take off the locknuts and washers, then knock out the cotter pins ; the stub-axle pins can now be extracted by tapping out downwards. The stub-axle Timken races and their shims should then be removed and the bottom bushes pressed out.

Fitting New Bushes

The new bushes should now be pressed in to the stub axles and carefully reamered out to suit the pins. In fitting these pins particular

care must be taken to ensure that they line up correctly with the Timken bearings, which are fitted at the top of the stub axle.

To carry on with reassembling, first of all fit each stub axle in position without any felt washers, and adjust the Timken bearings by means of the shims provided, so that the locknuts can be tightened down to leave the stub axles free to move, but at the same time without any signs of slackness. It will be necessary to remove or add shims as required to obtain this adjustment correctly. Having effected this procedure quite satisfactorily, next dismantle and reassemble again, but this time fitting at the same time the felt washers and retainers. It may appear on the second assembly that the stub axles are now tight, but as by the previous attention it is quite definite the races were adjusted correctly, any tightness found afterwards will be due only to the felt washers, which of course will very soon bed themselves and allow the stub axles to operate freely.

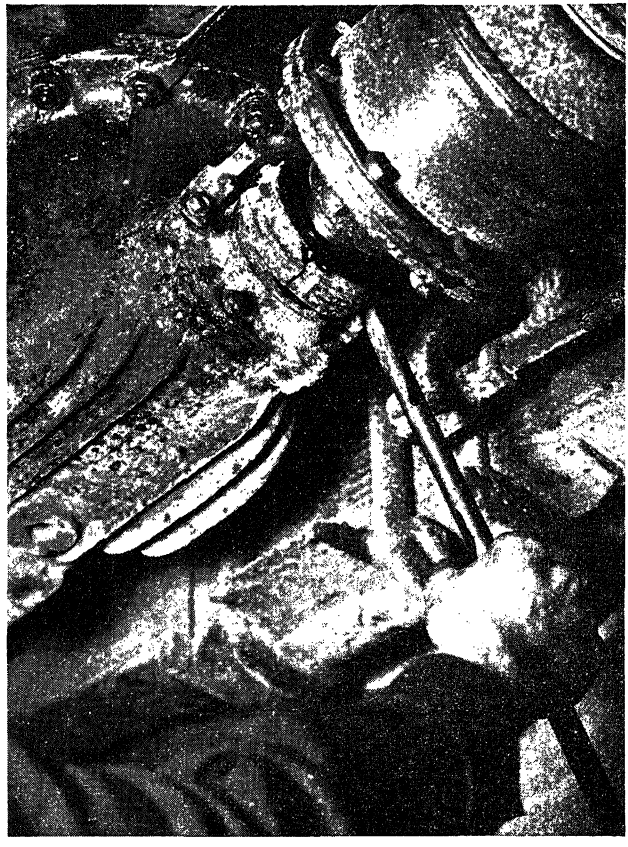


Fig. 2.—THE WORMSHAFT OIL-RETAINING GLAND AT THE FRONT OF THE DIFFERENTIAL BEING TIGHTENED BY MEANS OF A SPECIAL " C " SPANNER

The dust covers and brake shoes can now be reassembled and the hubs refitted. After fitting the hubs and races, fit the special " D " washers and hub nuts and nip up just tight. Then slacken back approximately one half-turn, and turn until the hole in the hub nut lines up with the hole in the " D " washer. Fit the grub-screw in hole, and then fit lockbolt through the hub nut and split-pin up. Completion of the

reassembling of the front axle to the chassis is then quite a simple matter.

REAR AXLE

The Gilford " Hera " rear axle is of the fully floating type and has the worm-driven differential unit fitted in the nearside of the axle casing, instead of the orthodox central-drive position. The reason for this is to obviate the obstruction of the differential lid causing difficulty in the gangway on passenger-type vehicles. With the differential offset to one side, the raised portion of the differential is in a position (probably under a seat or somewhere similar) in which it presents no difficulty to the body-builder as regards gangways, etc.

Axle Shafts

The two axle-driving shafts are of different lengths, due to the special design of axle, and consequently it is very important when ordering replacement shafts to stipulate whether the shaft required is for the nearside or offside. The shafts are fitted direct into the differential bevel wheels with a splined fitting and are secured at the hub ends by a splined driving dog. They can be easily removed by removing the nuts that secure the driving dog to the hub and also refitting is a simple matter.

In the event of an axle shaft breaking off short at the differential end, difficulty is sometimes experienced in removing the broken portion which is left in the differential. In such an instance, it will generally be found that the best way to remove this is to withdraw the opposite shaft and push a long bar right through the axle casing and thus eject the broken piece. Should this method fail to be successful, the only remedy is to remove the differential unit complete from axle.

To remove Differential

To take down the differential unit from the chassis it will first be necessary to withdraw both axle shafts and uncouple the Hardy Spicer coupling from the differential flange. It is then only necessary to remove the bolts that secure the differential to the rear-axle casing, and the differential is ready to be dropped. Before, however, completely removing all the securing bolts, the weight of the differential should be taken up on a jack and a rope fixed around the unit for lowering purposes. Having arranged this satisfactorily, remove the remaining securing bolts, and having taken the weight of the differential by means of the rope from above, through the trapdoor, remove the supporting jack and gradually lower the differential complete to the floor.

Differential

The differential is of very robust construction, both the wormshaft and wormwheel being rigidly mounted on large ball-and-roller bearings.

As a result there are no special adjustments to attend to after the differential is properly assembled. The only item that will require periodical attention is the oil-retaining gland at the front end of the differential, which may, when wear develops, allow oil to creep through. This can then be remedied by tightening up the special slotted gland nut by means of a suitable " C " spanner so as to rebed the special packing fitted in the gland itself (*see* Fig. 2).

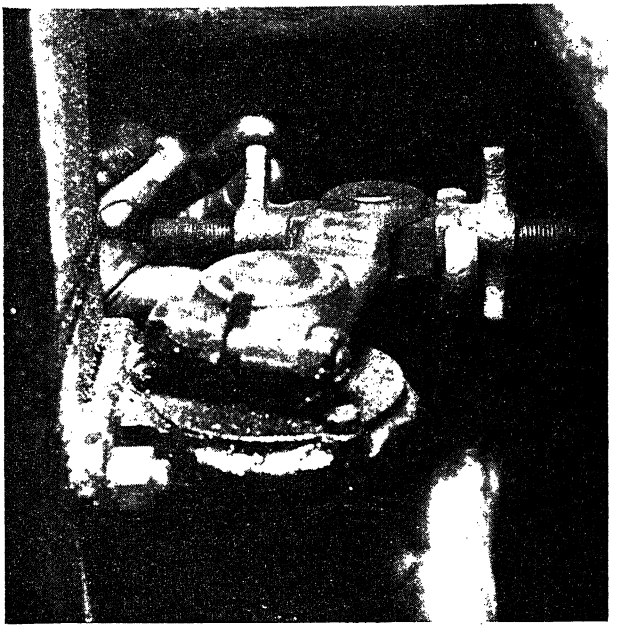


Fig. 3.—MASTER ADJUSTMENT FOR FOOT BRAKE

The locknut behind the turnbuckle is slackened, and re-tightened after adjustment has been taken up by means of the flynut.

When tightening up the gland nut does not prevent oil leaking, it is then obvious that a new packing is required.

Rear Hub Removal

To remove one of the rear hubs, first of all take off the wheels and withdraw the axle shaft. When this is done the special hub-locking device is exposed, and it will be seen to be very similar to that employed with the front hubs, excepting that the construction is much larger. The next operation is to remove the split-pin from lockbolt and withdraw locking bolt; after this extract the special set bolt which locks the adjusting collar to the " D " washer. Now it is necessary only to unscrew the adjusting collar and remove the " D " washer, when the rear hub is ready to be removed complete with bearings.

To reassemble Rear Hub

After fitting on the rear hub together with the Timken bearings, fit up next the special " D " washer and locking nut and fasten up quite tight. Then carefully slacken back the nut approximately one half-turn until the hole in the hub nut coincides with a hole in the " D " washer. Then screw the set bolt in position, which will lock properly this adjustment

for the bearings. Now all that remains is to fit the locking bolt into the adjusting collar, which will pull the split collar together and lock it securely on the threads of the axle tube. Then split-pin up and hub is double-locked in position.

STEERING

Adjustment

The steering gear is of the Marles type, which is, generally speaking, very troublefree. There are, however, two adjustments which may at some time need attention. The first adjustment concerns the roller assembly in relation to the cam. To raise or lower the mesh of these two parts the following procedure should be followed. Remove drop arm from rocker shaft and rocker shaft from steering box. Take off nut and washer from rocker-shaft bolt and withdraw bolt from rocker-shaft serrations, until serrations on bolt are just free of the rocker-shaft serrated hole. This will mean withdrawing the bolt about $\frac{3}{8}$ in. to $\frac{9}{16}$ in. With an ordinary spanner on head of bolt, turn bolt one serration or more as found necessary in a clockwise direction for raising the roller into the cam, or in an anti-clockwise direction to lower the roller away from the cam. Push bolt home again into rocker shaft and refit nut and lock-washer carefully in position. It should be noted that to raise the roller relative to the centre line of the rocker shaft, giving deeper engagement with the cam track, the bolt must be turned clockwise looking at the end of the bolt.

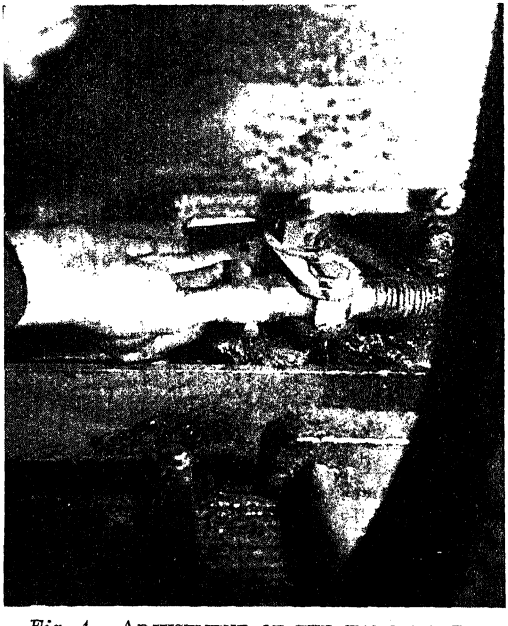


Fig. 4.—ADJUSTMENT OF THE HAND BRAKE

When this adjustment is correctly made it will be found that there is a slight amount of "backlash" at the two extreme ends of the cam and roller movement, but absolutely none in the centre or straight-ahead position. Care should be taken that the roller is not advanced so far into the cam that movement is stiffened. On the other hand, the adjustment must be close enough to ensure no trace of "backlash" in the central position of the cam and roller.

The second adjustment is between the steering-box and the column support.

Between the steering-box casting and the column support are a number of thin washers or shims. End play of the cam between its bearings may therefore be taken up by taking out some of the thin layers and thus allowing the thrust cone carried by the column support to enter farther into the steering box and thus come closer to the cam.

When this adjustment has been correctly made it should be such that after the column support is again bolted securely to the steering-box casting, the cam and steering-wheel shaft should revolve freely, but there should be no end play of same.

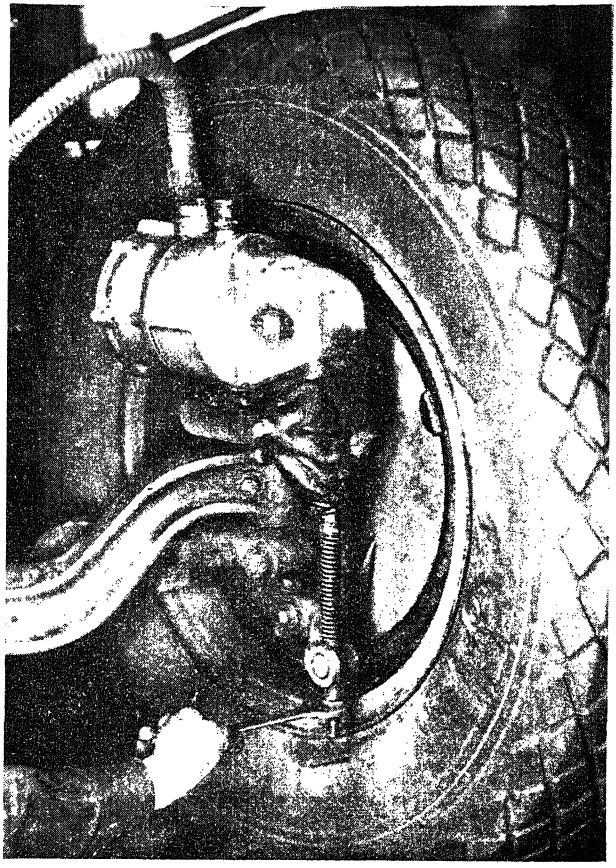


Fig. 5.—METHOD OF ADJUSTING THE FRONT WHEEL BRAKES

Between the steering box and bottom cover similar shims are inserted as those between the steering box and column support. These bottom shims, however, should not be disturbed, as they are correctly set by the manufacturers and are for the purpose of centring the cam relative to the rocker shaft.

Special Note.—Do not drive drop arm on to rocker shaft when reassembling. This should always be pulled on by nut at end of shaft. Do not interfere with the lockstop in the steering box.

Steering Track

The steering track rod is screwed right-hand and left-hand at each end for necessary adjustment. The correct front-wheel " toe-in " should be not more than $\frac{1}{8}$ in.

BRAKES

The braking system is very simple, and is assisted by a triple servo system which ensures very effective operation of the brakes at all speeds.

There is one pair of brake shoes in each hub, the rear shoes being 6 in. wide with a very large friction area. These shoes operate for the hand-brake as well as for the foot, and, due to the special design of link-up incorporated, the results are very good.

The Servos

The triple Dewandre Vacuum Servo system consists of a master or main cylinder and piston which controls two smaller cylinders. The master cylinder applies all its effort to the rear wheels alone, and is provided with a special valve (this is the only valve in the whole system), the two smaller cylinders being merely connected to this main cylinder by means of suction pipes and having no valves of any kind.

The master cylinder is coupled by means of a suction pipe to the induction pipe of the engine and controls the two supplementary cylinders, which are fitted to the front wheels. There is no mechanical connection between the front and rear brakes except by the suction pipes.

All details of the operation, etc., are dealt with in a separate article solely concerned with these units.

Adjustments

The foot-brake pedal is connected to the main servo, and from there the brake rods continue to a cross-shaft, thence to two special fulcrum levers, and finally finish with short rods to the rear-brake cam levers. The main adjustment for the foot-brake is by means of a master turn-buckle, which will be found about half-way along the chassis. This can usually be reached quite easily through the trapdoor provided in most coach bodies (*see* Fig. 3). Should it be necessary to equalise the brakes, this should be undertaken by adjustment on the short rods which go to the cam levers.

The adjustment for the hand-brake can be made by means of a large flynut which is fitted at the bottom of the hand-brake lever. This is easily accessible through the trapdoor in the driver's cab (Fig. 4).

If found necessary, individual adjustment can be made at each front wheel. There will be found provision for this adjustment at each of the front-wheel servo units, by means of the two short rods which connect these units to the front-brake cams (Fig. 5). No special care is necessary to balance the front-wheel brakes with this system. The adjustments should be just sufficient that when the shoes begin to rub, the adjusting nut is released by approximately half a turn. In making this adjustment care must always be taken to ensure that the front brakes are doing their full share of braking. The rear brakes will naturally give much longer

life and require less attention if the fronts are kept properly adjusted and are as a result working in correct harmony with the rear.

Special Note

It is important that the length of brake-rods is not altered. This applies particularly to the rod between the brake pedal and servo. This rod is carefully determined by the manufacturers when the vehicle is built, and there should be no need to interfere with same in the ordinary way.

TRANSMISSION

The transmission from the gearbox to the differential is arranged by large-diameter tubular propeller shafts incorporating Hardy Spicer universal joints, with the exception of the coupling immediately to the rear of the gearbox, which is a metal-enclosed Layrub type of universal joint.

The Layrub type of joint needs no attention at all as, being fitted with rubber bushes of special construction, there is no lubrication to worry about, or oil retainers, etc., to renew periodically. The time does eventually arrive, however, when the rubber bushes or metal joint holes become distorted through extensive usage, when a new joint becomes necessary. It is possible, if the joint has not gone too far, to renew the rubber bushes only, but this is a matter for the makers to deal with.

The remaining universal joints are, as previously stated, of the Hardy Spicer type and need very little attention, excepting careful and regular lubrication, which is effected by packing with the special grease recommended by the makers. Occasionally, these joints should be inspected to ensure that the cork gasket fitted to the casing retainer is sound and does not allow the grease to leak. If there is any doubt about this, the coupling should at once be removed and fitted with a new grease-retaining cork. Lack of lubrication to these joints can prove a very expensive matter.

Centre Carrier

The centre carrier is mounted on a chassis cross-member and consists of a very large and self-aligning ball race encased in a suitable housing. The front propeller shafts run direct to this assembly. The only attention the centre carrier needs is frequent lubrication, which is carried out by gear oil from the Tecalemit battery nipple situated on the nearside rear cross-member.

THE REPAIR AND MAINTENANCE OF ALL-STEEL BODIES

By A. F. HOULBERG

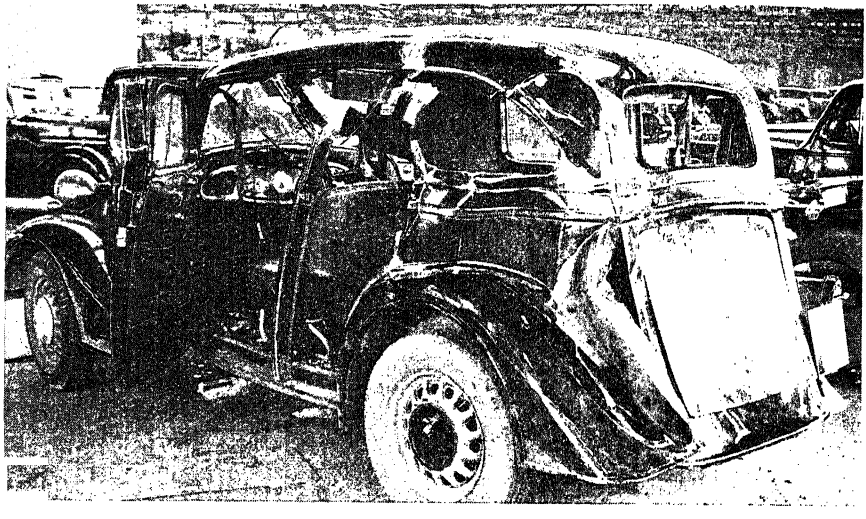


Fig. 1.—AFTER THE SMASH

This shows a Vauxhall Car of integral construction. The repair is illustrated in the following Figs. 2 to 8. A trimmer is shown in the above picture removing the interior trimmings. (*By courtesy of Shaw & Kilburn.*)

IN order to be able to carry out repairs effectively, an understanding of the basic constructional features of the all-steel body is essential.

The earlier all-steel bodies—those made prior to 1936 by the Pressed Steel Co.—consist of four main sub-assemblies which are welded together. The four sub-assemblies consist of:

(1) The scuttle assembly, which includes the windscreen frame and the front door pillars—or "A" posts, as they are often referred to.

(2) The right-hand side panel assembly, which includes the centre door pillar or "B" and "C" post, the rear door hanging pillar or "D" post, the rear-quarter panel, and the top and bottom sills.

(3) The left-hand side assembly, which is similar to the above.

(4) The rear panel assembly.



Fig. 2.—THE REPAIR—FIRST OPERATION

Cutting out the smashed section with shears (quarter panel). (*By courtesy of Shaw & Kilburn.*)

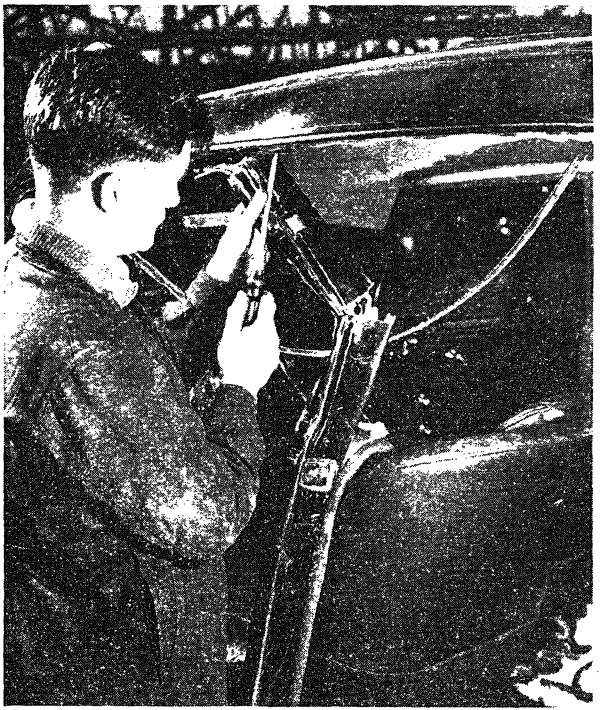


Fig. 3.—THE SECOND OPERATION

Removing the damaged centre pillar. (*By courtesy of Shaw & Kilburn.*)



Fig. 4.—THE THIRD OPERATION

Beating out edges of damaged portions of rear panel with planishing hammer and dolly. (*By courtesy of Shaw & Kilburn.*)

The later models are built up from five sub-assemblies, made up of:

(1) The right-hand side assembly, consisting of the scuttle side, the front pillar or "A" post, the centre pillar or "B" and "C" post, the rear pillar or "D" post, the rear-quarter panel, and the top and bottom sills.

(2) The left-hand side similar to the above.

(3) The rear panel assembly.

(4) The scuttle top panel.

(5) The wind-screen peak panel.

A still later type of all-steel body, employed, for example, on the Morris Ten (series "M"), is of monopiece construction, i.e. it has its chassis built as an integral part of the body. The repair of this type is dealt with later, as there are certain differences in procedure.

Dealing first with the normal type of construction, all component parts of the sub-assemblies are made from steel, mainly in the form of pressings, and welded together by one of three welding methods. These are oxy-acetylene welding, electric-resistance or spot welding, and electric arc welding. The type of welding used depends on the nature of the parts to be joined together and the nature of the joint.

The electrical methods of welding have certain advantages, but suffer from the fact that the apparatus is expensive and beyond the reach of all but the very largest repair establishments.

For the purpose of repair work, the oxy-acetylene method is perfectly satisfactory and has the advantage of low cost and ready portability.

OXY-ACETYLENE WELDING REPAIRS

The principles of oxy-acetylene welding are dealt with elsewhere and it is not necessary to repeat them here, but there are one or two points,

arising from the fact that the material to be worked on is thin, and the construction of the body, which need consideration.

Whilst a weld is being carried out, heat is being conducted away from the region of the weld to the surrounding portions of the structure, causing them to expand, and owing to their comparative thinness they are liable to buckle and distort unless precautions are taken.

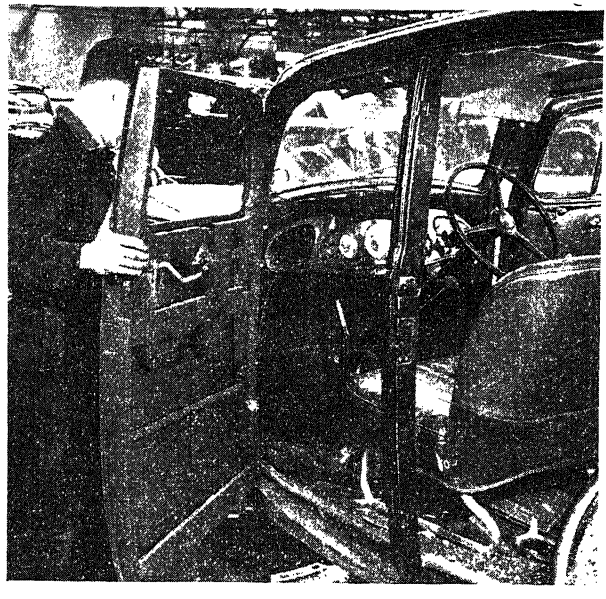


Fig. 5.—THE FOURTH OPERATION

Fitting new front door after new centre pillar has been fitted. (*By courtesy of Shaw & Kilburn.*)

Sound welds, accompanied by the minimum amount of distortion, can be made only by those possessing a sound working knowledge of the correct use and adjustment of the welding equipment. A study of the basic principles of the process should be made and considerable practice carried out with scrap metal of the same quality and thickness before any attempt is made to carry out any important welds.

First remove Solder

In many places on all-steel bodies solder is made use of for the purpose of filling gaps and irregularities on the surface of the body. Before a satisfactory weld can be made on metal so treated it is absolutely essential to remove all trace of the solder.

This is best accomplished by melting away the soldier with a blow-lamp as far as possible, and, while the metal is still hot, wiping away the remaining solder with a clean rag. A file or suitable scraper should then be used to remove the last traces of solder, so that perfectly clean steel surfaces are left for the welding process.

Welding Tip Sizes to Filler Rods

The correct choice of the welding tip is of great importance when operating on this material, for if the tip is too large the finished weld

will be very hard and will show a porous surface, while too small a tip will not produce proper fusion and will give a weld of low strength. A tip consuming approximately 200–300 litres or 7–11 cu. ft. of acetylene per hour will be found satisfactory for most work on a welded-steel body. The use of the correct size of tip will also minimise warping.

The employment of a filler rod of the correct size is also important. Should the rod be too large, the metal being welded will often burn before the filler rod becomes molten, while too small a rod will produce the reverse condition—the rod burning before fusion of the weld takes place.

The sheet metal employed on all-steel bodies requires the use of a filler rod of the purest possible iron, with a low carbon



Fig. 6.—THE FIFTH OPERATION

Placing new quarter panel section in position after beating out and reshaping rear panel. (*By courtesy of Shaw & Kilburn.*)

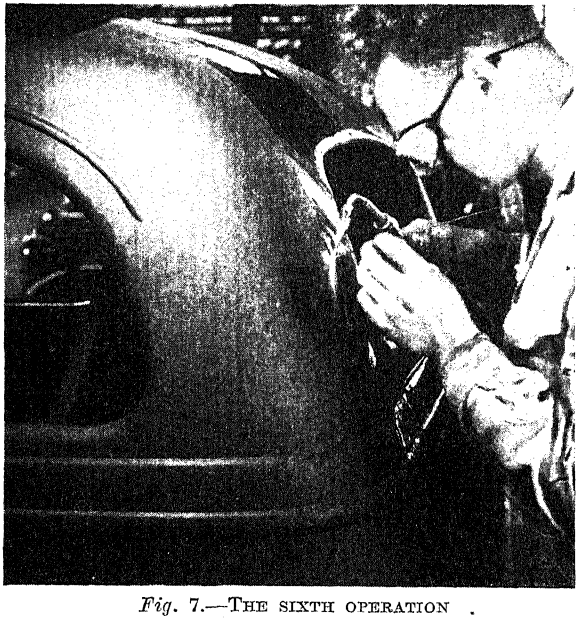


Fig. 7.—THE SIXTH OPERATION

Tacking the new panel in position with oxy-acetylene blowpipe. (*By courtesy of Shaw & Kilburn.*)

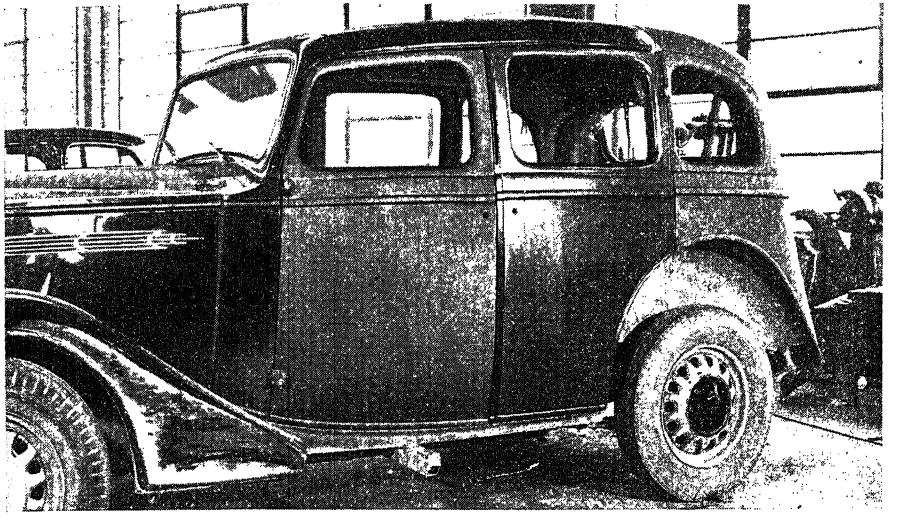


Fig. 8.—THE BODY REPAIR NEARING COMPLETION

Showing quarter panel and doors fitted. The integral construction of the Vauxhall car shown above consists of two quarter panels, left and right, rear body panel, roof side panels, left and right, and scuttle panel. (*By courtesy of Shaw & Kilburn.*)

content. That recommended is the one marketed and guaranteed as being 99·84 per cent. pure iron.

When welding, take care to keep the filler rod clean and free from contact with rust, as this is an enemy to a good weld. Welding rods should be kept in a dry place and be free from rust when used.

Welding Hints

The flame should be adjusted to neutral, i.e. neither oxidising nor carburising, and should be applied to the weld at an angle of approximately 70°, with the point just touching the metal. The filler rod should not be applied to the weld until the metal of the weld is completely molten, and when applied should be brought into direct contact with the molten metal and not dropped into the weld by pre-melting in the welding flame.

It is most important that the flame should not bend or spread over the sides of the weld when it is brought into contact with the weld. The point of the flame should be held in such a position that the outer end of the bright cone just licks the metal.

How to prevent Buckling

It is essential that buckling or warping should be kept to a minimum, in order to avoid further corrective repair work.



Fig. 8A.—REPAIRING DAMAGED BODY WITHOUT REPLACEMENT OF PARTS

This is an untouched picture of a smash, and Fig. 8B shows what can be done without replacing any panels.



Fig. 8B.—REPAIRING DAMAGED BODY WITHOUT REPLACEMENT OF PARTS

The panel was dressed out with hammer and dolly. No metal filling used, only the ordinary cellulose filler before cellulosing.

(*Both pictures by courtesy of Messrs. L. F. Dove, Ltd., Croydon.*)

The use of wet asbestos sheeting placed along each side of the weld about $\frac{1}{4}$ in. from the edge of the metal will help to localise the heat and prevent undue distortion. The work should also be " tacked " at frequent intervals with a weld of from $\frac{1}{8}$ in. to $\frac{1}{4}$ in. in length, to ensure that the components are in their correct relative position and further reduce distortion.

The use of wet asbestos sheet when carrying out welds on work that has already been finished or partly finished is also recommended, as this reduces the area of discoloration round the weld and the amount of repolishing required subsequently.

REPAIRING DAMAGED BODY

Some Essential Tools

All-steel bodies seldom fracture even in severe accidents, and they may often be saved for further use if correctly treated in the first instance.

One of the most useful tools for preliminary attention to a damaged body is the body jack, or stretcher. These tools are obtainable from Harvey,

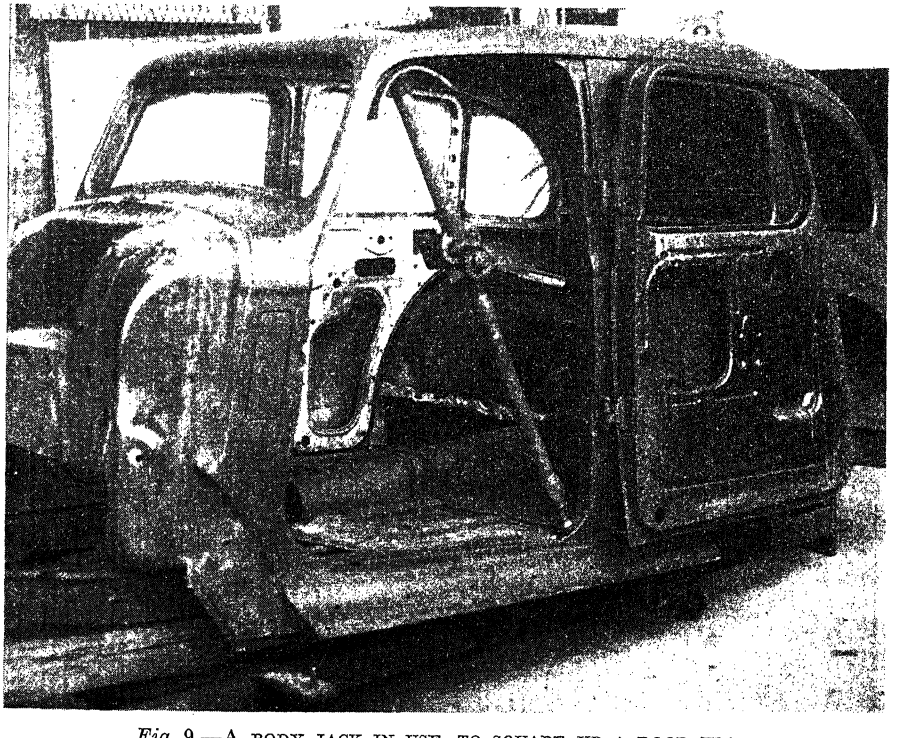


Fig. 9.—A BODY JACK IN USE, TO SQUARE UP A DOOR FRAME

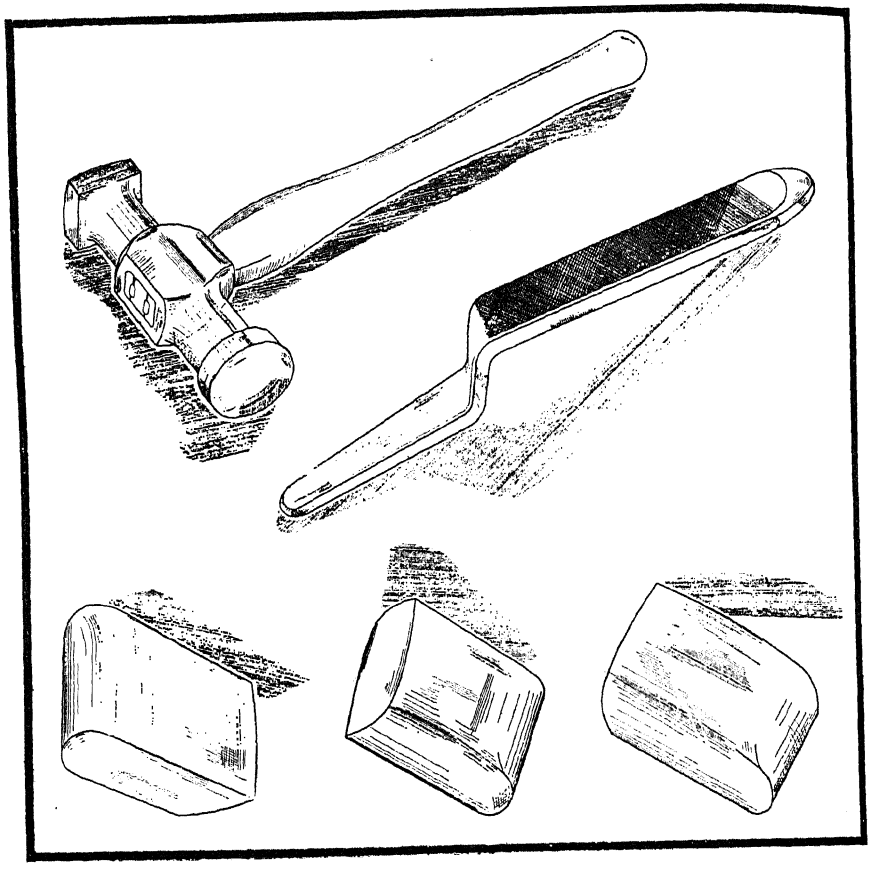


Fig. 10.—SOME OF THE NECESSARY STRAIGHTENING TOOLS FOR TAKING OUT DENTS IN WINGS AND PANELS

Showing pein hammer, various shaped dollies, and a paddle made from an old milling file.

Frost & Co., of 150 Great Portland St., London, and consist of an extensible jack with a range from 24 in. fully contracted to 96 in. fully extended, to which may be attached variously shaped end fittings, or dollies, which are specially adapted to push out damaged panels or square up distorted bodies. The detailed use of this tool will be described later.

A set of sheet-metal working tools, consisting of a wooden mallet, hide hammer, planishing hammer, bumping hammer, various shaped dollies, files, file with cranked handle for finishing large flat areas, cranked paddle (made from an old heavy milling file), twisting wrenches, drift pin, lifter, and scribe awl.

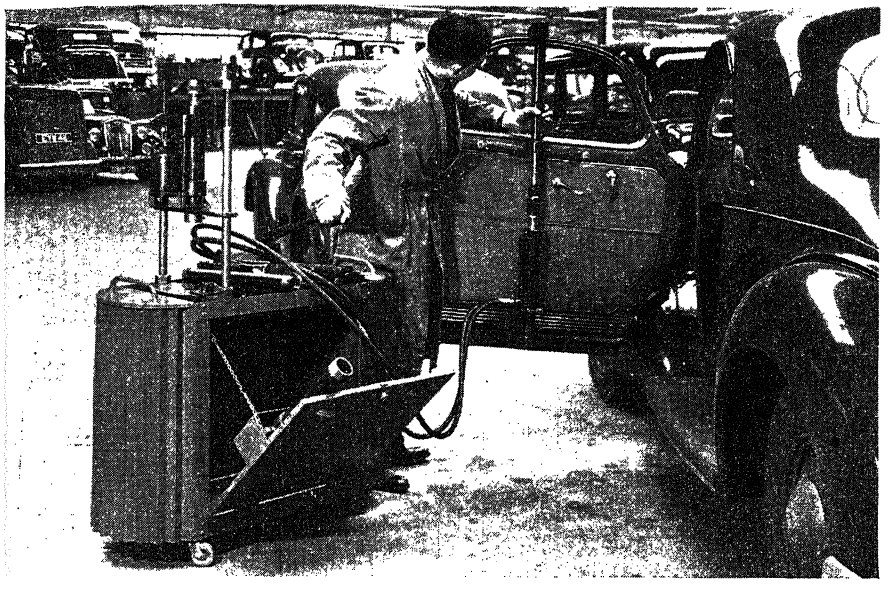


Fig. 11.—USING REMOTE CONTROL HYDRAULIC JACK

Top of door being pulled back into position. The jack is being operated at a distance by means of special hoses. (*By courtesy of Equipments Ltd.*)

The First Operation on Damaged Body—Checking Alignment

Most bodies which have been involved in an accident of any consequence are distorted in some way, and the first essential is to check up the alignment of the body and correct any portion which has been forced out of square by the impact.

Check up the door openings, the "A," "B," "C," and "D" posts for squareness, also the windscreen panel.

Removing the Trimming

Before applying any corrective measures to the body it is essential to remove any trimming in the locality of the damage which may interfere with the operation.

Most of the trimming is built up on a millboard foundation, which is covered with the upholstery material and either tacked in place or attached to the body by snap fasteners.

The door trim panels are fastened to the body of the door by snap fasteners in the majority of cases, and are released by inserting a screwdriver under the head of the fastener and prising it outwards. Care should be taken when doing this not to tear the upholstery. On some cars the door-window moulding must be removed before the trim panel can be detached, while on other models the door inside trim plate cannot



Fig. 12.—USING REMOTE CONTROL HYDRAULIC JACK FOR PUSHING TURRET TOP OF CAR OUT AFTER ACCIDENT

be removed until the trim panel is withdrawn, when it can be unclipped from behind.

The centre pillar trimming is built up in a similar way to the door trimming, but is fastened by gimp pins, which are driven into strips of paper-cord filler fixed to the pillar. On some models the panel is held to the pillar by drive screws, and where this method is used it will immediately be apparent.

The lower-quarter trim panels are held in position by a series of tacks along their top edge, and down the rear door pillar. They can be prised off after removing the tacks and the window moulding.

The scuttle trim panels are carpet panels, and are held in position by tacks, which are driven into the special trimming strips attached to the door pillar. On some models these are found to be attached by a screw, a bifurcated rivet, and a series of gimp pins, all of which must be removed before the panel can be withdrawn.

Windscreen and Side Headers

Later models have these components attached by drive screws driven into the windscreen top rail and gimp pins driven into the roof flange. Drive screws and gimp pins must be removed and the front end of the side headers must be raised to give access to tacks fastening the windscreen headcloth in position.

Earlier models have their headers fastened in position by brads driven into trimming strips attached to the panelling.

Headcloth

The headcloth material is cut to shape and has strips of cloth (or listings) sewn on at intervals. These strips of cloth are tacked to the

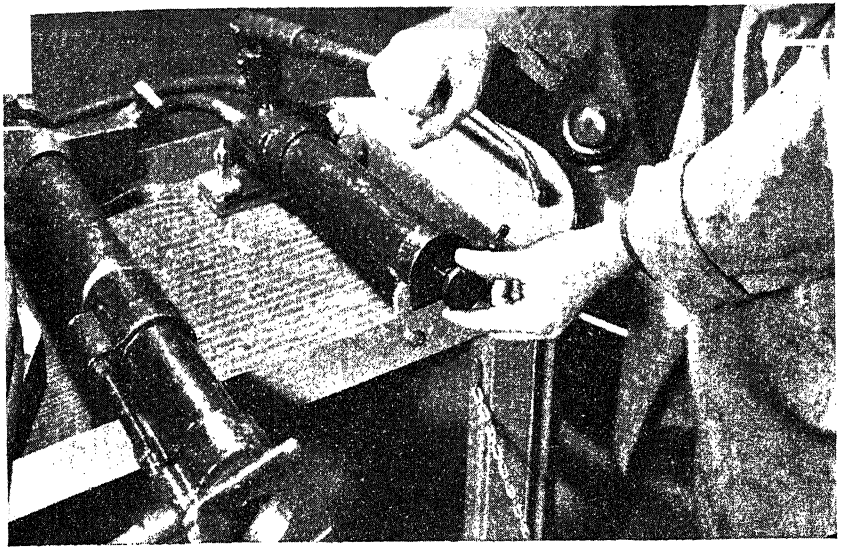


Fig. 13.—HYDRAULIC JACK CONTROL EQUIPMENT

Turning the button which determines the push or pull action of the hydraulic remote control jack illustrated in Figs. 11 and 12. (*By courtesy of Equipments, Ltd.*)



Fig. 14.—LARGE BENDING BAR, INCLUDED IN HYDRAULIC JACK EQUIPMENT, BEING USED ON THE BUMPER OF A CAR

(*By courtesy of Equipments, Ltd.*)

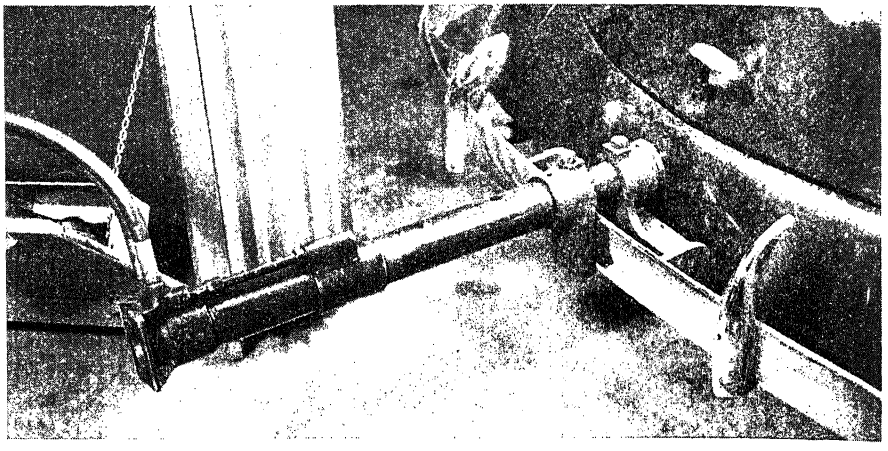


Fig. 15.—USING LARGE HYDRAULIC BENDING CLAMP AND THE CLAMP TO TAKE A BEND OUT OF A BUMPER WITHOUT REMOVING FROM THE CAR

(*By courtesy of Equipments, Ltd.*)

roof cross-members and thus suspend the headcloth in position. The front, rear, and side edges are tacked to trimming strips attached to the upper part of the body.

Rear-seat Squab

The rear-seat squab is made up on a steel-spring frame and is retained in position by two clips which engage the angle strip which forms the rear belt ledge.

To remove the squab it is necessary to take out the bolts in the bottom retainers and draw the bottom of the squab forward, applying at the same time pressure on the top of the squab so that the retainer clips become disengaged, enabling the squab to be lifted clear.

Later bodies are fitted with squabs having tabs at the top, which should be unclipped. If the hinge bolts are removed from the wheel arch, the squab can then be lifted out.

The Front Seats

Earlier models are removed from the body by raising the locking device for the seat position adjustment and sliding the seat rearwards.

On later models the seats can be removed by unscrewing one screw from the rear end of each seat runner.

The Roof Assembly

Both sliding and fixed head roofs of the earlier type can be removed from the body as a complete unit if the windscreen header, side header, quarter panel moulding, upper rear-quarter trim panel, and upper rear trim panel are first removed.

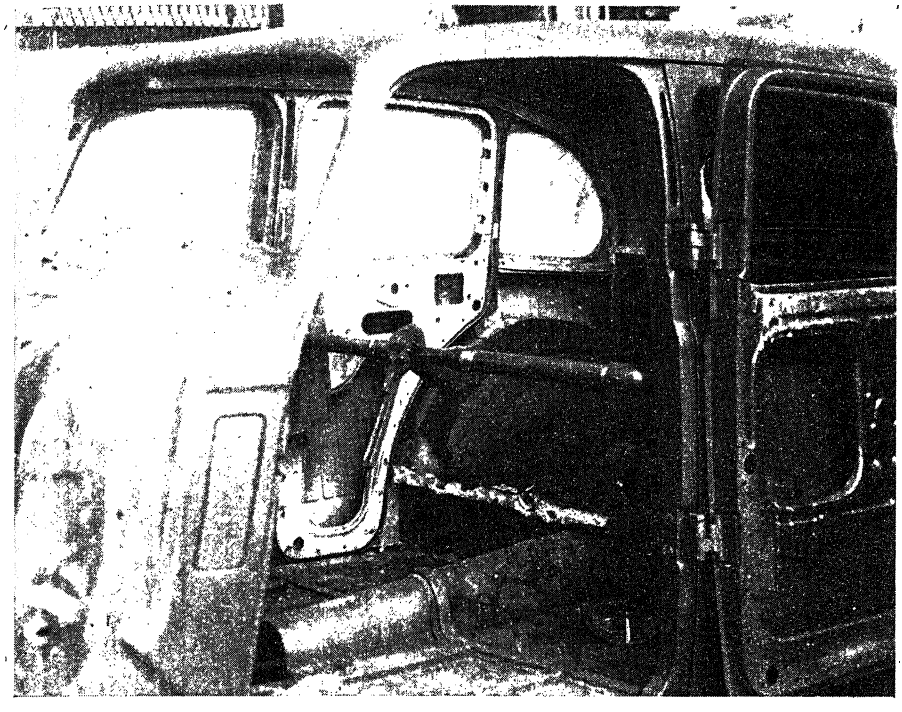


Fig. 16.—BODY JACK IN USE TO FORCE OUT A CENTRE PILLAR WHICH HAS BEEN BENT

To avoid bending the undamaged pillar, a stiffening bar should be inserted between the pillar and the foot of the jack.

The tacks holding the headcloth to the roof sides and front and rear edges should then be withdrawn, permitting the headcloth to hang from the roof centre so that it may be lifted with the roof unit after the fixing screws attaching it to the roof opening flange have been withdrawn.

The roof assembly on later models is removed in the same way except that it is not necessary to disturb the rear and quarter upper trimming.

Removing Door Glasses

To remove the door glasses on the earlier models it is first necessary to remove the garnish rail, trim panel, and unscrew the four setscrews which attach the window-regulating mechanism to the inner door panel. This will enable the regulator unit to be disconnected from the glass cross-channel.

The glass should now be lifted to approximately the half-open position and then withdrawn upwards and inwards towards the inside of the door. This will cause the glass to leave the channels.

Later models employ felt-lined rigid metal channels held in place by

drive screws at their top and centre, and have their bottom end equipped with a metal tab which hooks under the support for the glass run.

To remove the glass it is first necessary to remove the drive screws and slide the channels downwards sufficiently to release the bottom fixing. The glass should then be run up almost to the top of the door, so that the end of the regulator arm can be removed from the slot in the bottom glass channel. The glass and channels can then be raised upwards and inwards bodily until clear of the door.

Removing No-draught Ventilators

The no-draught ventilators are fixed to pivot brackets attached to the door moulding.

To remove the ventilator on the earlier models it is necessary to withdraw the six drive screws attaching the moulding to the door. The ventilator can then be removed from the moulding by undoing the thumb-nut from the quadrant assembly and removing the lower pivot bracket by taking out the two setscrews which hold this component to the angle support. If the ventilator is then slid inwards and downwards, it will be freed from the top bracket. In a later type the ventilator is fixed by three screws and the centre channel, and it can be withdrawn after removing the window moulding and the three screws.

Yet another type of ventilator in use is that fitted with a regulator, and to remove this it is first necessary to remove the window moulding, door trim panel, regulator handle, and recess pad. The four screws which hold the ventilator-regulator mechanism should then be loosened and the three screws removed from the ventilator frame.

This will enable you to pull the ventilator towards the inside of the body at the top and to remove it in an upward direction.

The regulator mechanism can now be removed if necessary by taking out the four screws which were previously only loosened.

Rear Window and Rear Quarter Windows

To remove these windows it is necessary to withdraw the rubber moulding surrounding the glass, which is held in place by an adhesive composition. When replacing the glass, fit the rubber moulding round the edge, with the joint at the top of the glass, and hold it in position by tying a piece of thin cord round the edge, leaving the loose ends on the outside of the glass. Treat the edge with "Bostick" or similar composition and place glass in position from inside the body. Getting an assistant to hold the glass in position on the inside, pull the string from around the glass on the outside of the car. This will bring the edge of the rubber moulding with it, which should now lie flat on the surface of the rear panel.

Removing Centre Channel from Front Doors

If it is necessary to remove the front door centre channel, this can be done without difficulty by removing the door-window moulding, unscrew-

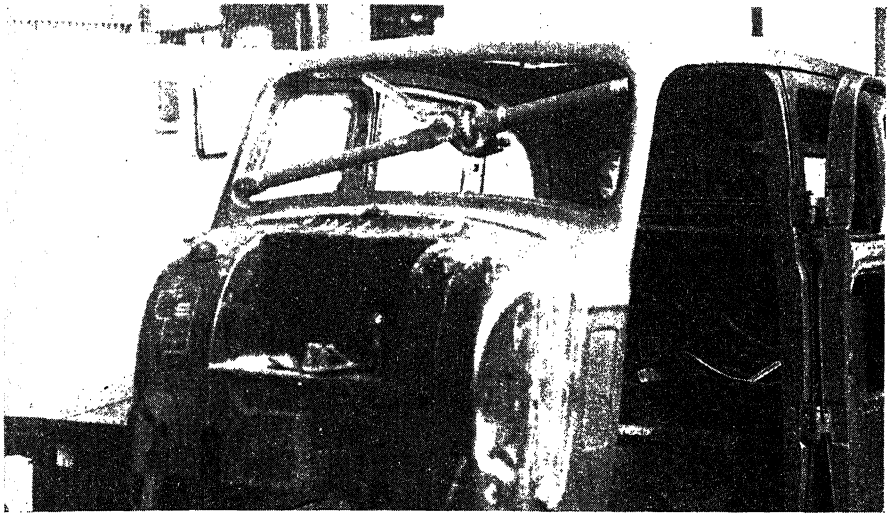


Fig. 17.—SQUARING UP WINDSCREEN OPENING, USING BODY JACK

ing the top screw and three lower screws from the channel, and lifting it out through the window opening.

Squaring up the Body

All parts that are found to have been displaced should be forced back into their correct location with the help of the body jack.

For instance, in the case of a distorted door opening the body jack should be inserted diagonally between the two corners of the door pillars on the diagonal which is too short and the jack expanded until the door frame has been pushed back into its correct shape.

Similarly, a body which has been pushed out of square sideways should be rectified by using the body jack diagonally between the sill and the top rail on the short diagonal.

All portions of the body should be carefully squared up in this way before any attempt is made to remove damaged portions for replacement.

When the body has been squared up as accurately as possible, individual damaged panels can then be pushed out again, employing the body jack for the purpose, together with a suitable dolly.

Straightening damaged portions of the body is often facilitated by heating the metal in the region of the bend and pounding it with the wooden mallet.

It is well to remember, however, that the metal of the body is very thin and that application of the body jack can cause local buckling at the points where it is applied unless the parts are suitably protected by steel bars clamped to the components, or unless suitably shaped dollies

are used on the ends of the jacks. If protecting steel bars are used, the pressure from the jack should always be applied to the steel bars and not to the body material itself.

The Replacement of Parts

Experience with steel bodies will soon show that it is very often possible to recondition parts which look hopelessly damaged, and it is to the repairer's advantage to do so whenever possible, as this is cheaper than replacing the component, and the saving in money will earn the goodwill of the customer.

Whenever possible straighten the parts and weld in preference to replacing.

Local Repairs

Having squared up the body to your satisfaction, it should be carefully examined for local blemishes, and for this purpose the palm of the hand should be passed over the surface, when any irregularity can easily be felt. When doing this, always wear cotton gloves, as this keeps the surface of the metal free from grease, prevents possible damage to the palm of your hand, and assists the detection of blemishes.

If a high degree of accuracy is required, a sheet of abrasive cloth may be used instead of a cotton glove.

Hammering

When using the hammer, it is important that only light blows be used and that care is taken that the blows fall squarely and solidly upon the face of the dolly block or planishing head.

Large Dents

A sandbag will be found most useful for removing large dents, particularly on a painted unit. A bag of oval shape, approximately 8 in. by 6 in. and some 4 in. thick, is a useful size.

When a large buckle or dent takes place, the metal is somewhat stretched in the process, and to remove the dent it is necessary to shrink it back to its normal contour.

This is achieved by heating the damaged portion to a cherry red by a blow-lamp or blow-pipe, and, holding the dolly block underneath, hammering the heated part with the wooden mallet until the metal is cool. This process should be repeated until the dent is completely eradicated.

Small Dents

Small dents and depressions should be removed by the use of a handblock and a paddle made from a heavy milling file—with the teeth still intact.

The dolly should be held in contact with the highest point of the dent and the paddle applied to the opposite side, using light blows until the dent is removed.

Some parts of the panelling are masked on one side by an inner component or panel, and in such cases it is not possible to use the dolly block and paddle. The correct treatment here is to punch a hole with the drift pin through the inside panel, forcing out the depression, or using the lifter for raising the dent.

Small dents on a finished body may sometimes be driven out by the use of a sharp-pointed scribe awl driven through the trimming.

The removal of dents from wings and panels by hot metal. Shrinkage is dealt with on pages 26 to 38 of this volume.

Posts

Door frames or posts that have become dented present another difficulty, since it is by no means an easy matter to obtain access to the inside. The best method of dealing with the situation is to weld a piece of welding wire to the centre of the low spot, form the outer end of the wire into a handle, and then heat the metal round the wire to a cherry red. A steady pull can then be applied to the handle formed on the wire and the dent pulled out to match up with the surrounding metal of the post.

Thin Spots

Where the metal has become thin, through the original working, or the subsequent damage, repair by the methods just described may not be practicable, and recourse will have to be made to patching.

It should here be noted that wrinkles or ridges should not be removed by the process of filing, as this greatly weakens the body structure through thinning of the already thin metal. Any such blemishes should be shrunk by heating to cherry red and hammering with the wooden mallet.

Patching

Where the nature of the damage is such that straightening is impracticable, the part may still be repaired by the insertion of a patch.

It is first of all necessary to remove the damaged portion of the unit by cutting it out with a cold chisel or hacksaw and cleaning up the edges, with a file, so that they are smooth and symmetrical.

Now cut a patch from a piece of sheet steel of the same gauge, and shape the patch roughly to the contour of the component to be patched. Fit this patch into the opening prepared and trim its outer edge so that there is a clearance all round it equal to the gauge of the metal.

You should now tack the patch in position on the unit and finally shape it to conform as closely as possible to the contour of the surrounding metal.

Place plenty of wet asbestos sheet round the weld and weld all the edges together, continuing to shape the patch to the correct contour with dolly and bumping hammer.

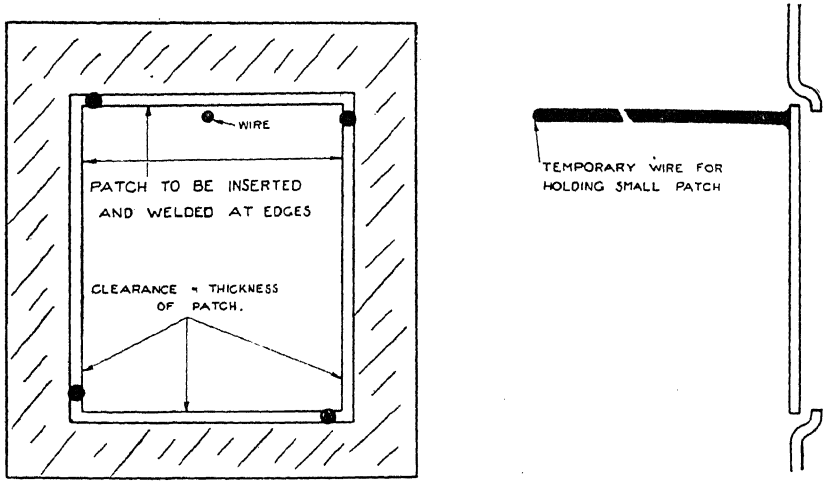


Fig. 18.—PATCHING

Small patches which are difficult to hold in position may be dealt with quite easily by temporarily welding a length of welding wire to act as a handle.

When correctly shaped, remove excess weld on face side and straighten up if necessary with dolly block and bumping hammer.

Sometimes a patch is difficult to hold in position owing to its size or location and the heat of the welding torch. The difficulty may be overcome in such cases by welding a short length of welding wire to the patch and using this as a temporary handle with which to hold the patch in position while tacking. The wire can afterwards be cut off and the spot cleaned up.

Forming Patches

It is often necessary to raise or bump out the patch to shape from the flat sheet so that it matches up with the body contour.

For this purpose a ball-pein hammer and a wooden or lead raising block with several spherical depressions of varying size should be used.

When raising work on the block described, the pein end of the hammer is used, and it is of great importance to remember that the forming should start at the outer edge and gradually work towards the centre of the area to be dealt with.

An error which is often made is to hammer too hard while raising the centre, and thus produce a curve of greater depth than is required. This

stretches the metal, which has then to be shrunk again in order to rectify matters, and as this is not an easy matter the operator is advised to be very careful with the use of the hammer when forming.

Replacing Components

In cases where a component, such as a door pillar, has been buckled beyond repair, the old post can be sawn off about 3 in. from each end, and a new one inserted by welding after it has been cut to the right length.

In extreme cases it may be necessary to insert an extensive new area of the body structure, and this can be carried out quite successfully by obtaining a replacement panel from the makers and cutting away the defective portion of the body.

Quite extensive repairs of this nature can be carried out on all-steel bodies, and it is not necessary to remove the body from the chassis for this on the latest models, although it is of course necessary to remove all interior trimming and hardware in the region of the repair.

A few examples of extensively damaged bodies are shown in the illustrations, together with indications as to where the body should be cut for replacement purposes. It will be seen that each repair will call for a different treatment, but the general scheme employed will be gathered from the illustrations.

Breaking Welds

In the repair of damaged bodies it often becomes necessary to break the original weld in order to remove the damaged part.

The procedure to use when parting the weld differs, of course, from the welding process employed in making the weld.

To break a spot weld the best method is to drill a hole of approximately $\frac{3}{16}$-in. diameter through the centre of the weld and to force the panels apart by driving a cold chisel between them. When the new panel is being welded in position the new weld—which will be made by the oxy-acetylene process—can be made through the hole which was made when parting the spot weld, thus filling it again.

Where the original weld was made by the oxy-acetylene process the weld should be cut with a cold chisel and hammer. If the weld was filled over with solder, the solder should be melted and wiped away.

Some of the welds on all-steel bodies—notably that between the side panels and rear panel—are made by butt welding the edges together by the electrical-resistance welding process. Such joints can usually be parted by means of a cold chisel and hammer, directing the blows against the panel which is to be scrapped.

If difficulty is encountered in parting such a weld in this manner, the joint can be heated up with an oxy-acetylene torch so that the fused edges of the panels are softened, thus assisting in the breaking of the weld.



Fig. 19.—THIS BODY HAS A BADLY CRUSHED PANEL SCUTTLE AND "A" POST

In such a case, the scuttle and post should be cut away where indicated, and fresh panels welded in. Do not forget first to square up the body with the body jack.



Fig. 20.—THIS BODY HAS A BADLY CRUSHED "A," "B," AND "C" POST

Here it is advisable to cut away the damaged portion, as shown by the dotted lines, after carefully squaring up the body with the body jack.

Scuttle Repairs

On bodies built prior to 1936 it is necessary to remove the bolts holding the body on to the chassis in order that it may be lifted some 6 in. to give access to the bottom weld if attention is required at this point.

To separate the scuttle panel from the side panels it is first necessary to break through the oxy-acetylene weld at the front end of the roof side panels where they join the top screen panel.

The spot welds on the face of the " A " post half-way down the screen pillar and just above and below the door lock striker where the side panel half laps on the " A " post should be drilled through.

Working from the inside, a cold chisel should be driven between the side panel and the scuttle half of the " A " post to part the spot welds.

With a hacksaw cut through the lower part of the body, forward of the door opening, as closely as possible to the oxy-acetylene weld, which can easily be located from the inside.

This will release the scuttle unit, which can now be withdrawn.

Rebolt the sides of the body in position and also bolt the new scuttle assembly in position on the chassis, thus using the chassis as an assembly jig.

Now reweld the roof side panels to the new scuttle. Clamp the two halves of the " A " post together and weld together through the holes drilled for parting the spot welds.

Release the body from the chassis and raise till scuttle-panel lower edge is clear of chassis. Reweld the scuttle panel to the forward end of the body sill.

Clean off all welds and bump them down where necessary for filling with solder, as will be described later.

Removing Scuttle Pressing on later Models

On later models the scuttle panel is flash welded to the side panels, and it is necessary to break through the welds between scuttle top panel and the scuttle side panels, which are formed in one piece with the body side panels.

It is also necessary to break through the welds between the scuttle top panel and the windscreen bottom flange, and also through the welds down the front pillar and dashpan side flanges.

Further welds which must be broken through are located between the front pillar bottom bracket and the side of the dashpan ; between the front pillar and its reinforcements to the scuttle top panel and " A " post lower reinforcement.

The reinforcement for the windscreen top panel should now be removed by breaking through the welds in the windscreen top panel where it joins on to the forward ends of the body side panels, and by using a hacksaw cut through the joint seam, which can easily be seen from the inside.

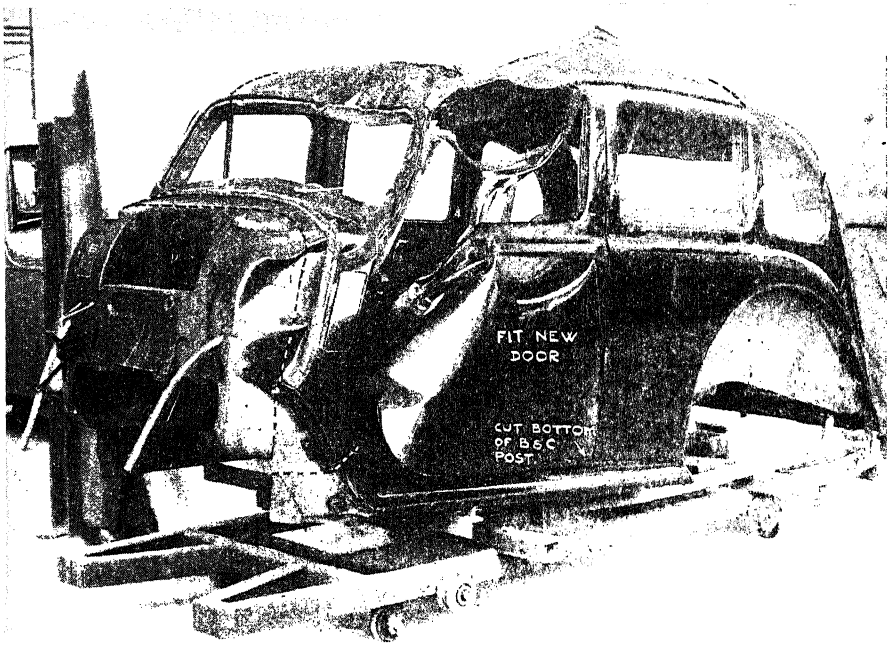


Fig. 21.—How to repair damage of this nature
Cut away the upper and lower windscreen panels and the forward end of the side panel at the points indicated. New panels should then be welded in and a new front door fitted.

The joint seam between the scuttle top panel and the scuttle side panels can be sawn in a similar way.

A temporary windscreen frame is necessary to locate correctly the components on reassembly.

The new scuttle should be located in position, butting up against the side panels, and the extreme ends of the joints should be tacked in position. The whole length of the joint should now be tacked at intervals of 2 in., making sure that it is correctly located, and finally welded over its entire length.

The dashpan can now be replaced and welded round the hood ledge, front pillar, and windscreen bottom rail through the holes made when breaking the old welds.

Weld the top screen panel reinforcement along the windscreen to the fixed support, and weld the front pillar lower reinforcement.

Finally weld the bottom bracket to the dashpan and the dashpan bottom flange to the side sill.

Replacing Rear Panels

Two types of rear panel joints have been used, the earlier type of joint being butt welded while the later type is flash welded. Which type

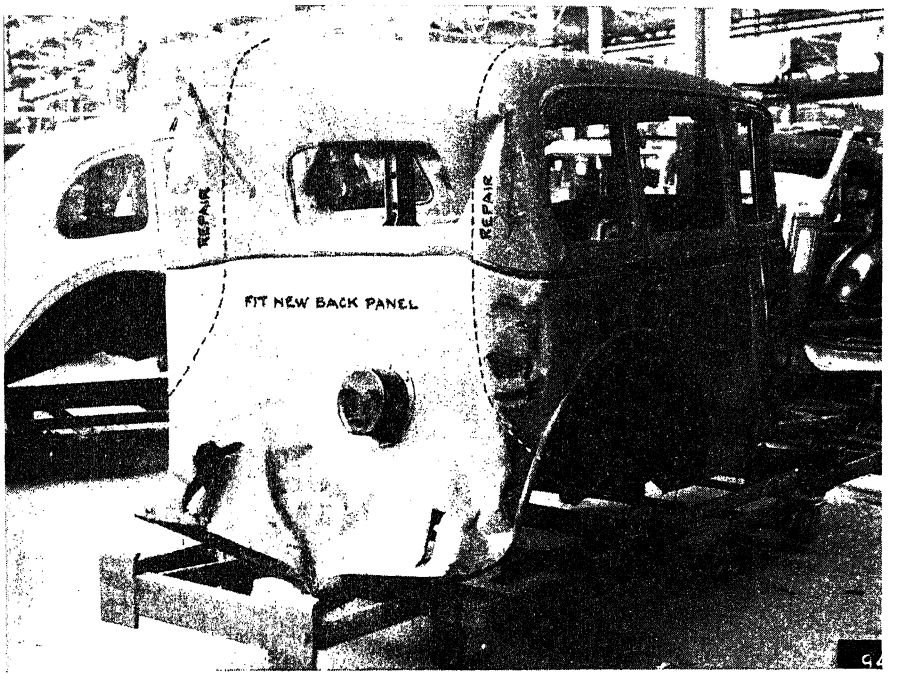


Fig. 22.—CRUSHED BACK PANEL

With a crushed back panel of the type shown, the panel should be cut away, the damaged portions of the side panels repaired, and a new rear panel fitted.

of welding is used on any particular body is easily seen as soon as the interior trimming is removed, as the continuous molten seam of the flash welding is unmistakable.

To remove the back panel it is first necessary to withdraw the body holding-down bolts and raise the body approximately 6 in. above the chassis.

The usual $\frac{3}{16}$-in. diameter holes should now be drilled through all the spot welds on the components concerned, and, using a cold chisel, the seat pan should be removed.

The spot welds holding the roof-opening corner brace to the rear panel should now be broken, but do not break the welds which locate the brace to the side panels.

Using a hacksaw or oxygen torch, cut away the back panel approximately 1 in. inside the original point so as to leave that amount of extra metal on the body side panels.

Locate the new rear panel in position, letting it lap over the 1-in. wide strips left on the side panel. The new panel can be located approximately by lining up its edges with those of the original butt welding.

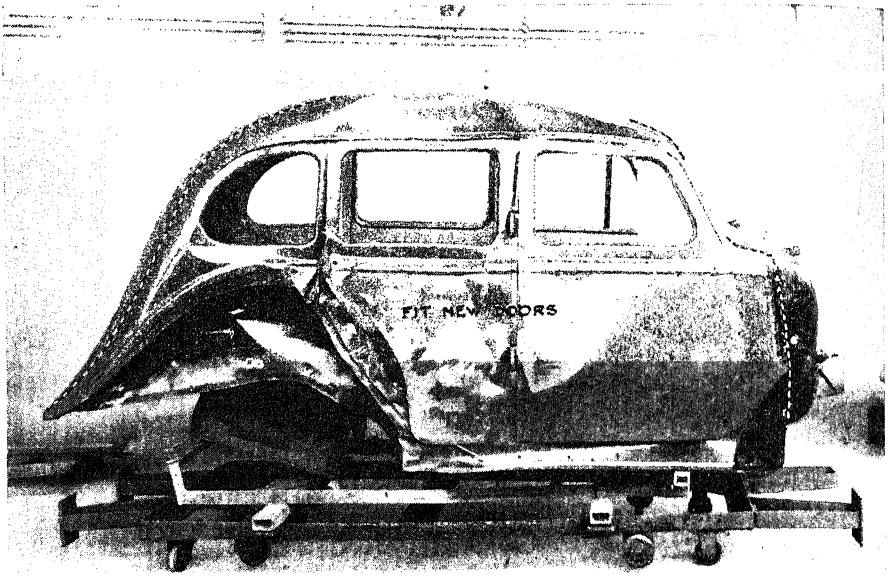


Fig. 23.—IN A SMASH OF THIS NATURE, IT IS ADVISABLE TO CUT AWAY THE SIDE PANEL COMPLETELY AND TO WELD IN A NEW UNIT

The location of the cuts is clearly indicated by the dotted lines.

When properly located, weld the bottom ends of the panel with the oxy-acetylene torch and tack the upper ends of the panel in position on the side panels. Lower the body on to the chassis, bolt into position, and check up alignment of new panel. If correct, weld the complete length of the overlapping panel, clean off, and fill with solder as necessary.

Reweld the roof-opening corner bracket in position through the drilled holes and replace the seat pan, also welding in position.

The roof-opening corner braces should be released from the rear panel in the same way. Welds will be found between the rear quarter-light* frame and the rear-light upper and lower rails. These welds should be broken through.

The welds of the luggage-shelf side supports, where they are attached to the wheel arch, should also be broken, together with the undershield reinforcement where it is welded to the wheel arch.

Using a hacksaw or cold chisel, the rear panel can now be cut out as close as possible to the original joint, but on the " side-panel " side of the joint, leaving the old joint on the rear panel.

Obtain a new rear panel and hammer a ledge, metal-thickness deep, all down its edge, so that when placed in position the faces of the side panels and rear panel lie perfectly flush, taking care to see that the lip

* Window openings are called " lights " in the trade.

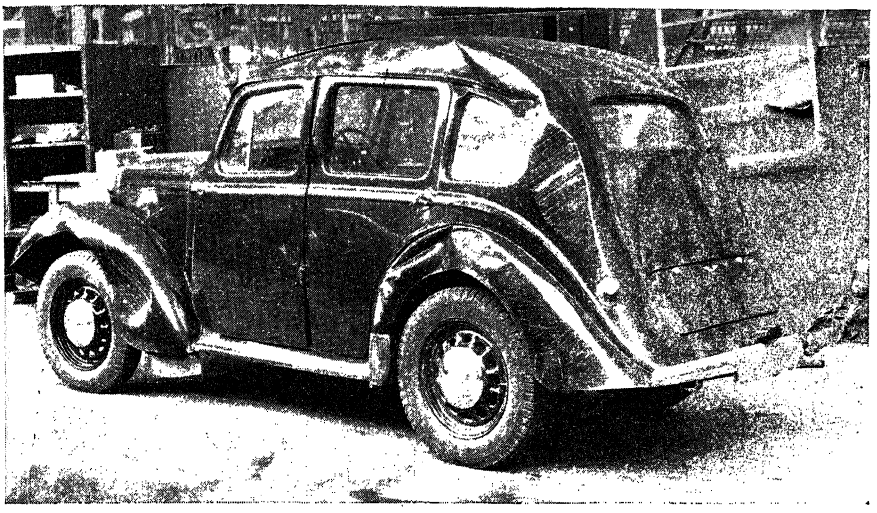


Fig. 24.—A BODY WITH A BADLY DAMAGED SIDE

A completely new side can be welded in after squaring up the body and cutting away the damaged parts, as will be seen from the three following illustrations.

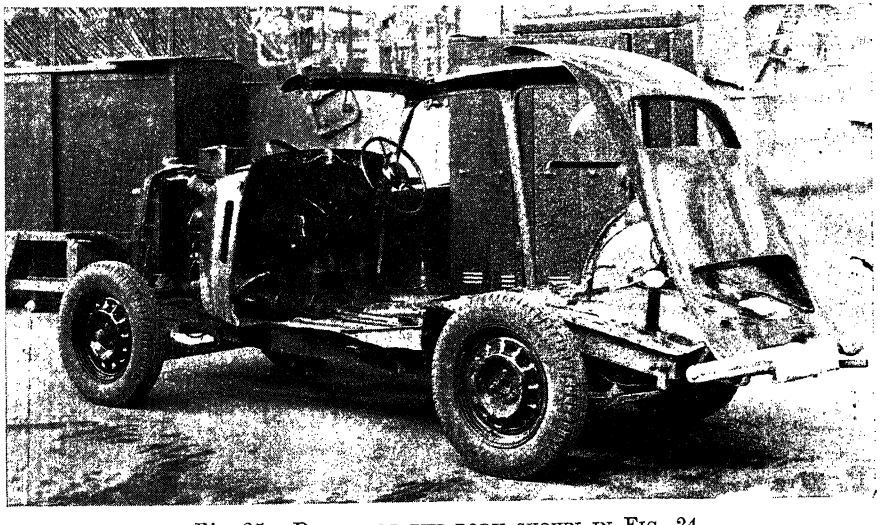


Fig. 25.—REPAIR OF THE BODY SHOWN IN FIG. 24

Here the damaged parts have been cut away and the body is now ready for the reception of the new side assembly, as shown in the next figure.

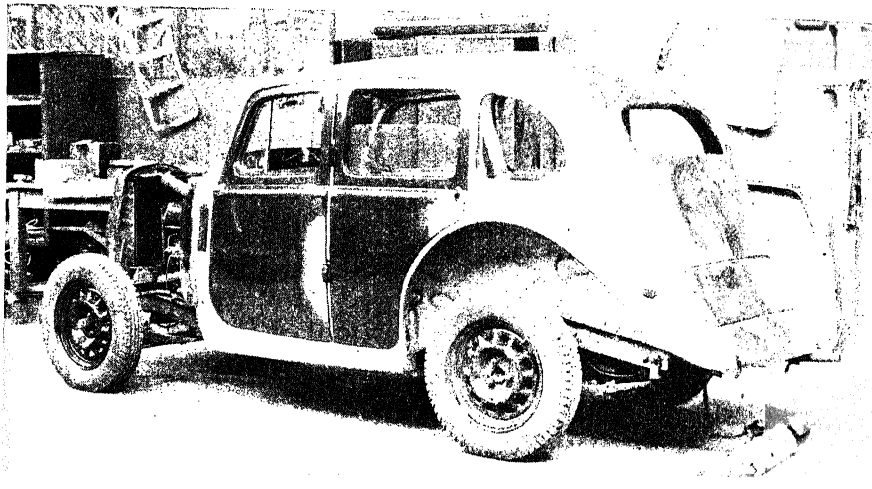


Fig. 26.—THE ABOVE PICTURE SHOWS THE NEW SIDE ASSEMBLY AFTER IT HAS BEEN WELDED INTO POSITION

All the joints have now been filled with solder, as described on pages 246–248.

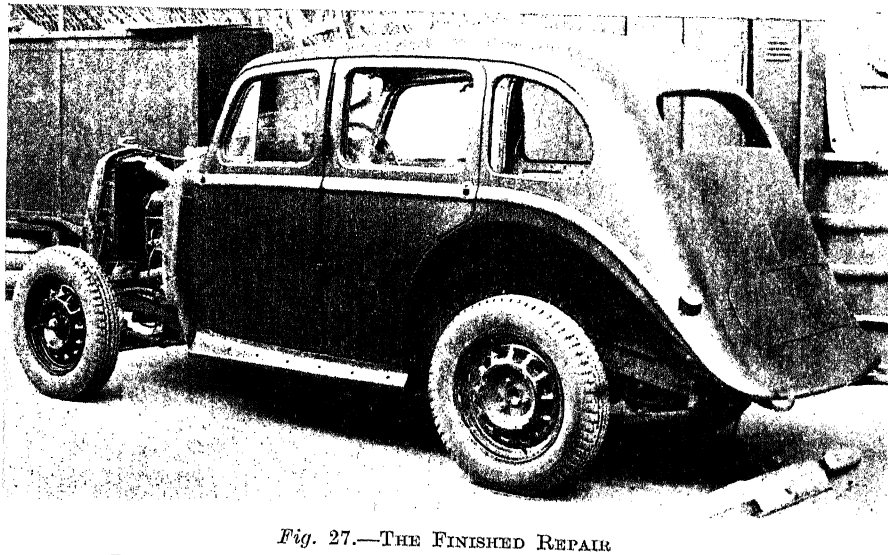


Fig. 27.—THE FINISHED REPAIR

It will be noted that the body has received its first coat of priming.

of the ledge is in alignment with the edge of the corresponding side panel.

You may now proceed to weld the joint, straightening, bumping, and filling with solder as required.

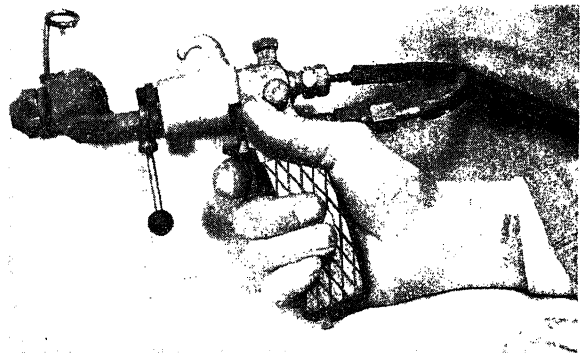


Fig. 28.—ACE SOLDER SPRAY GUN FOR FILLING IN DENTS IN WINGS AND PANELS

The use of this tool is illustrated in Figs. 29–32. It is connected to acetylene line at 10 lb. pressure and compressed air line at 40 lb. pressure. Instead of compressed air, oxygen at 25 lb. may be used if more convenient. (*By courtesy of Equipments, Ltd.*)

Replacing Body Side Panels

The body side panels are "one-piece" pressings, and when assembled to the scuttle assembly and back panel form the complete body.

The method of parting the forward end from the scuttle assembly has already been fully dealt with under "Replacing Scuttle," and the parting of the rear end under "Replacing Rear Panel," so that it is unnecessary to repeat these instructions.

It is, however, important to bear in mind that slight differences in procedure are necessary in view of the fact that the "good" panels now to be saved were the "bad" ones in the previous operations.

For this reason, instead of completely removing the seat pan in the butt-welded bodies, it is necessary only to break the welds holding the pan to the side which is to be removed; to break the roof-opening corner brace from its attachment to the side panels, and to cut the panel on the "side-panel" side of the butt weld. In this case, too, the chassis may with advantage be used as an assembly jig to correctly locate the components before welding.

In the case of bodies which are flash welded together it is necessary only to break through the welds at the forward end on the side which is to be removed; to remember to break the welds of the roof-opening corner brace at the end where they are attached to the side panels, and to break through the seam joint of the rear panel on the rear-panel side, leaving the welded portion on the side panel.

The Finishing of Welds

In order to smooth over the irregularities of welds, torch soldering is recommended, as this obviates weakening the weld by excessive cleaning, which would seriously reduce the thickness of the metal.

The solders recommended are those known as "tinman's" solder,



Fig. 29.—FILLING IN DENTS—FIRST OPERATION
Cleaning dent to be filled in prior to tinning.

which is an alloy of 60 per cent. lead and 40 per cent. tin, and "plumber's" solder, which contains 70 per cent. lead and 30 per cent. tin. Tinman's solder, because of its greater proportion of tin, alloys more readily with the surface of the sheet steel, but plumber's solder remains in a plastic condition over a greater range of temperature—from 509° F. down to 358° F.—within which range it can be moulded to any desired shape.

Where it is desired to build up a contour with solder, the sheet steel must first of all be cleaned thoroughly. Rust, scale, welding oxide must all be removed by means of emery cloth, or a polishing head if available.

The clean metal surface is now gently heated with a blow-lamp and a paste-type soldering flux applied with a brush. The tinman's solder is then applied to the surface and rubbed with a wad of hemp over the surface of the steel, so that it becomes coated—or tinned—with solder. This is the foundation for the plumber's solder which will be used subsequently to build up the contour, and the success of the final result depends upon this "tinning" operation.

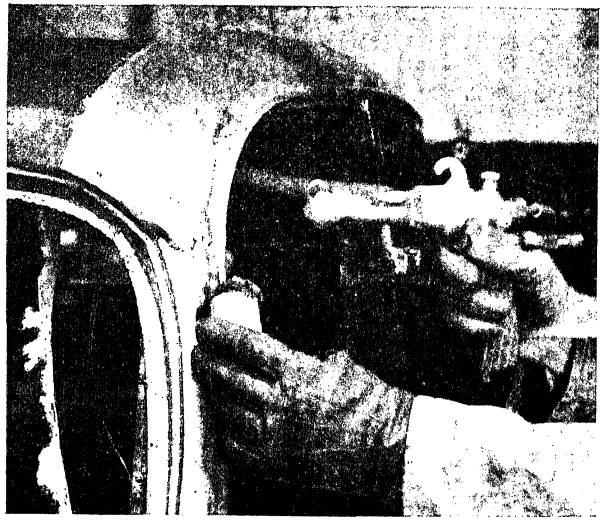


Fig. 30.—FILLING IN DENTS—SECOND OPERATION
A film of tinner from a tube is spread over the dent. The flame from the ace solder gun is then directed on the tinner, causing it to flow. When cold, the excess tinner is wiped off with steel wool, and the job is ready for spray soldering.

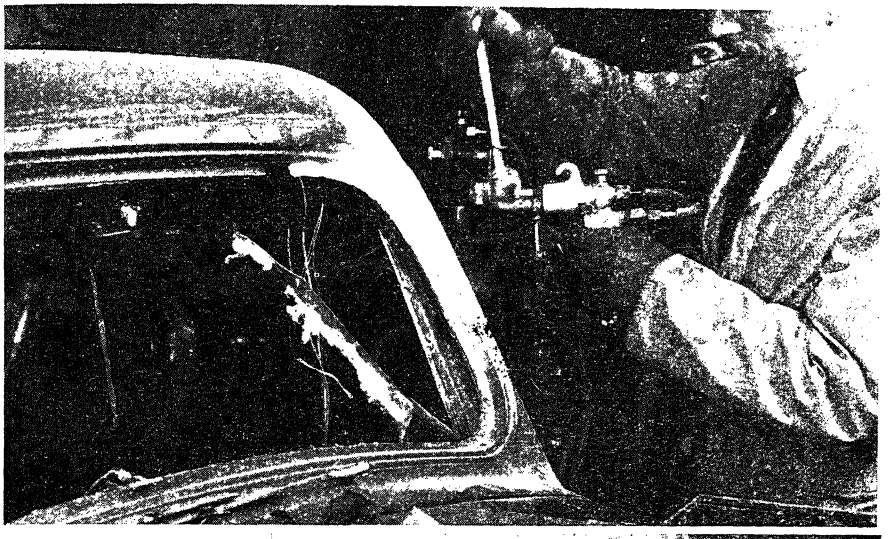


Fig. 31.—FILLING IN DENTS—THIRD OPERATION

Spraying the solder, which is in stick form, mounted at the head of the gun.

Filling with Solder

When the surface has been thoroughly "tinned" a little more flux is applied and the part again gently heated with the blow-lamp. The plumber's solder is now melted on to the surface and maintained in a plastic condition by careful application of the blow-lamp whilst it is moulded to the desired shape



Fig. 32.—FILLING IN DENTS—FOURTH OPERATION

After the dent has been sprayed with solder, the surface of the solder is moulded as required with a paddling block and a special lubricant which does not carbonise on the work, while the solder filling is heated with the torch. The surface may be finished with a file and emery paper.

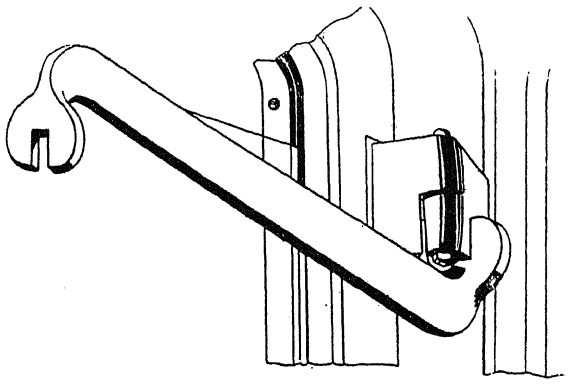


Fig. 33.—ADJUSTING DOORS

Where the doors are both hung on the centre pillar, a setting tool of the type shown should be used to set the doors away from the pillar.

with a paddle made of hardwood.

Frequent immersion of the paddle in palm oil during the operation assists in the manipulation of the solder, but if palm oil is not available boiled linseed oil, lard oil, mutton tallow, or machine oil may be used.

The method of finishing welds and filling in dents in wings and panels, using a solder spray gun, is shown in Figs. 28–32.

Door and Window-regulator Handles

On the later types of steel bodies the inside door handles are provided with a pin passing through the crank and handle, which is prevented from coming out by the escutcheon plate, which is in turn held forward by a spring. To remove the handle it is necessary to push back the escutcheon plate to a point where the pin is exposed and push out the pin with a small punch.

Earlier models have the handle fixed in position by a magnetised key engaging in a slot in the handle and the spindle. This key is held in position by the spring-loaded escutcheon plate in a similar manner to the later model, but in some instances a rubber pad replaces the spring.

Other models are fixed in position by a spring-loaded catch which engages a slot in the shank of the handle, and which can be released by inserting a pin punch in the small hole provided in the boss of the handle and holding aside the spring while the handle is being withdrawn.

In yet another model the door handle is held in position by a spring-loaded disc incorporated in the escutcheon plate which engages across the corners of the remote-control spindle. To remove this handle it is necessary to push round the tag formed on the underside of the handle, pulling the handle towards you at the same time.

Door Striking Plates and Dovetails

The striking plate is held in place by four screws which screw into holes tapped in a steel block held in a cage inside the door pillar. Removal of the four screws releases the striker plate.

The dovetails are fitted in a similar manner, but are adjustable horizontally rather than vertically.

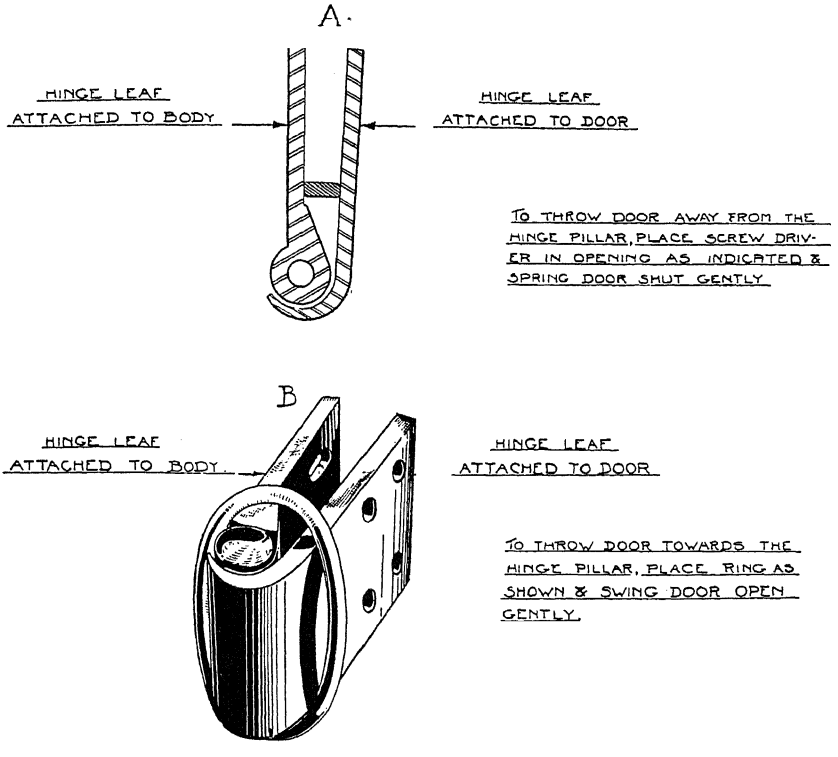


Fig. 34.—THE METHODS TO EMPLOY FOR SETTING HINGES

Door Checks

To remove the check on recent models, remove the bolt in the check link from the sill and swing the link round to the door panel, which will enable it to slip out of its slot.

On the earlier models it is first necessary to remove the body trimming to give access to the two screws holding the check in position. When these screws are removed, push the check back through the slot in the post and that in the door and remove the door trimming panel to retrieve the check from inside the door.

Adjusting Doors

When a body has been repaired it is usual to expect that a certain amount of adjustment has to be undertaken to ensure smooth shutting.

The position of the door in the door opening is adjusted by bending the blades of the hinges in the appropriate direction.

To set the door away from the hinge pillar the door should be opened, a screwdriver inserted between the hinge blades, and the door closed until the correct amount of set is attained.

To set the door more closely towards the hinge pillar a chain link of appropriate size should be slipped over the hinge and the door sprung open slightly.

Another method of setting the hinge is to use a twisting wrench, but this should only be used to set the door away from the hinge pillar, the chain link being used for setting in the other direction.

Some models have both the front and rear doors hung from the centre pillar, and these have to be dealt with differently.

To set the doors away from the pillar the screwdriver is inserted between the hinge blade attached to the door and that fixed to the pillar, and the door closed as before. To throw the door towards the hinge pillar it is necessary to insert a wedge in the shut pillar, close the door, and give the hinge leaf attached to the door a sharp blow with a caulking tool or drift close up to the door frame.

MONOPIECE CONSTRUCTION

Body and Underframe Repairs on the Morris Ten (Series "M")

In the repair of the Morris Ten (Series "M") car the same general principles and methods are employed as for normal all-steel bodies already described, with only the slight modifications entailed by the special form of construction employed in the production of this car, which has its chassis built as an integral part of the body instead of taking the form of a separate unit as in orthodox practice. Naturally, this scheme of monopiece construction introduces certain differences of repair procedure, which we propose to deal with in this section.

The first essential in the proper repair of the car under consideration is a thorough knowledge of the separate units from which it is constructed, so that the position of the various joints may accurately be located when a repair is called for, and the correct replacement units obtained from the manufacturers.

Reference to the two accompanying Figs. (35 and 36), showing the various component parts of the Morris Ten separated, will enable you to follow the details of the construction and will also indicate which replacement parts to requisition in order to deal with any repair however extensive it may be.

From the illustrations it will be seen that the two members which take the place of the normal chassis side members are built up of two pieces joined at the middle by flash welding. This facilitates repairs to the forward or rear ends, as only one-half of the side members need be

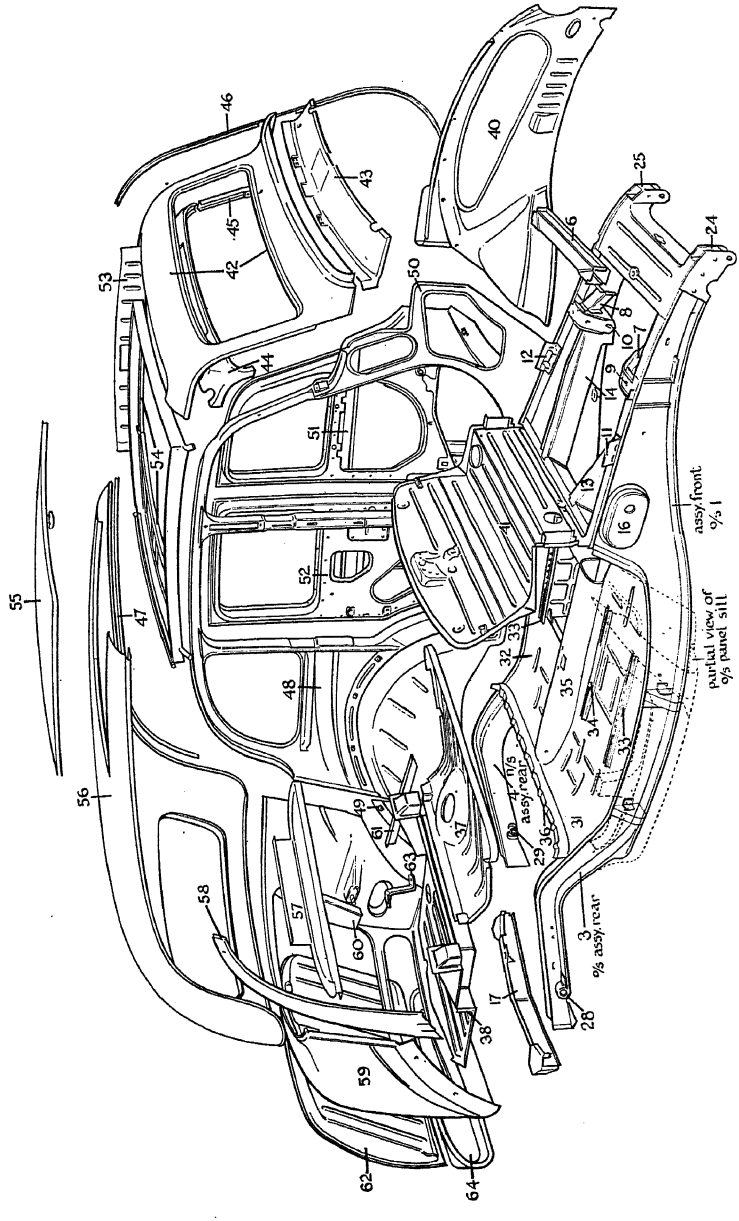


Fig. 35.—THE SEPARATE PANELS FOR THE MONOPIECE CONSTRUCTION OF THE MORRIS TEN (SERIES "M")

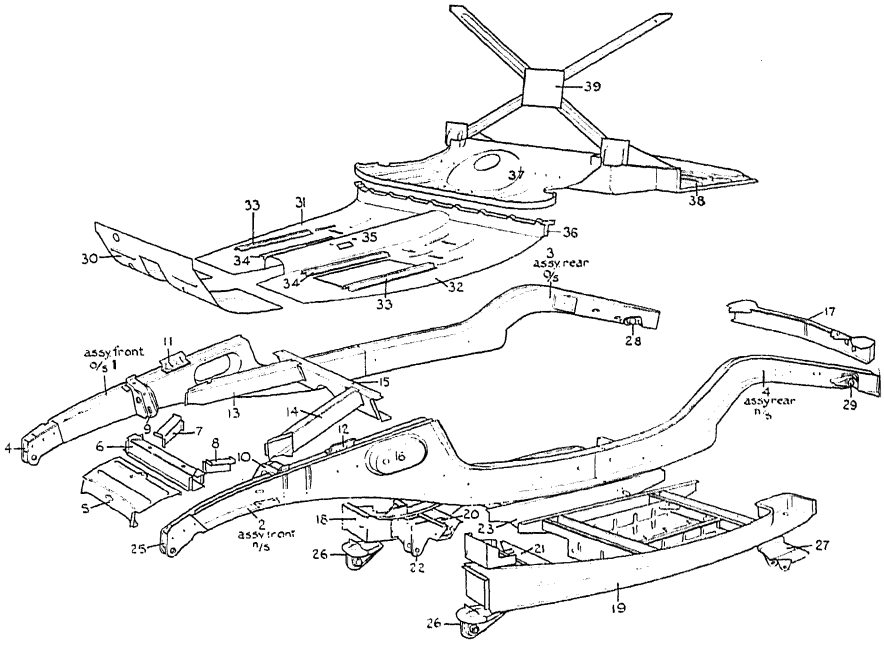


Fig. 36.—COMPONENTS OF UNDERFRAME, MORRIS TEN (SERIES "M")

replaced in the majority of cases when the car has been extensively damaged.

The side members are connected together by a series of cross-members, in a similar way to the normal chassis, and the forward end is stiffened by two diagonal members. It will be noted that the frame side members are assembled with their open sides outwards, and are stiffened over the centre portion by a sub-frame assembly which carries the front and rear spring anchorages at its four corners. This sub-assembly also carries the toolbox and the lower half of the tubular propeller-shaft tunnel. The centre portion of the frame is covered by a sheet-metal tray which functions as the floor and incorporates the upper half of the propeller-shaft tunnel. Forward of this metal tray is a curved pressing which forms the toe-board, while another pressing at the rear forms the rear-seat tray, which is in turn welded to another tray pressing, which serves as the support for the horizontally disposed spare wheel.

The body superstructure consists of side-panel assemblies containing the "A," "B" and "C" and "D" posts, the wheel-arch panel, a portion of the scuttle panel, and the lower shroud reinforcement. This structure is welded to the frame side members and then extended forward by welding the wing valance assemblies in position.

At the rear the side assemblies are joined together by the trunk panel,

LIST OF REPAIR PANELS, MORRIS TEN (SERIES "M")

With "Identity Numbers" as indicated in the "Exploded View" illustrations (Figs. 35 and 36)

Description	*No. Reqd.*	*Part No.*	*Identity No.*
Side-member assembly (front) O/S	1	95068	1
,, ,, ,, (front) N/S	1	95069	2
,, ,, ,, (rear) O/S	1	95070	3
,, ,, ,, (rear) N/S	1	95071	4
Front-splasher assembly	1	84943	5
Front cross-member assembly	1	95072	6
Stiffener (front cross-member to engine bracket) O/S	1	84525	7
,, (front cross-member to engine bracket) N/S	1	84526	8
Front engine-bracket assembly O/S	1	83967	9
,, ,, ,, ,, N/S	1	83968	10
Stiffener (front shock absorber) O/S	1	83985	11
,, (front shock absorber) N/S	1	83985	12
Frame-brace assembly O/S	1	83958	13
,, ,, ,, N/S	1	83959	14
Dash support cross-member assembly	1	95013	15
Spacer (chassis to valance)	2	84538	16
Rear cross-member assembly	1	83964	17
Stiffener assembly (main floor) O/S	1	95073	18
,, ,, (main floor) N/S	1	95074	19
Floor cross-member assembly (front) O/S	1	95075	20
,, ,, ,, ,, (front) N/S	1	95076	21
Clutch pedal-bracket assembly	1	84510	22
Tunnel (lower)	1	84993	23
Front spring front bracket assembly O/S	1	84918	24
,, ,, ,, ,, ,, N/S	1	84919	25
Front spring rear bracket assembly	2	83982	26
Rear spring front bracket assembly O/S	1	83952	—
,, ,, ,, ,, ,, N/S	1	83953	27
Rear spring rear bracket assembly O/S	1	83956	28
,, ,, ,, ,, ,, N/S	1	83957	29
Front floor panel assembly	1	95077	30
Floor side assembly O/S	1	84950	31
,, ,, ,, N/S	1	84951	32
Seat runner (locking)	2	84003	33
,, ,, (plain)	2	84002	34
Tunnel assembly (upper)	1	84949	35
Heel-board assembly	1	84500	36
Lockheed-hose bracket	1	83989	—
Seat-pan assembly	1	84994	37
Spare-wheel floor assembly	1	95078	38
Squab cross-brace assembly	1	105420	39
Front-valance assembly O/S	1	105490	—
,, ,, ,, N/S	1	105491	40
Front wing stay support O/S	1	105402	—
,, ,, ,, ,, N/S	1	105403	—
Dashpan assembly	1	105421	41
Windscreen panel (S.H. Saloon)	1	105339	42
,, ,, (F.H. Saloon)	1	105915	—
Windscreen lower rail	1	105419	43
Windscreen hinge-bracket assembly	1	105480	44
Upper panel shroud assembly (inner) O/S	1	105980	—
,, ,, ,, ,, (inner) N/S	1	105981	45

LIST OF REPAIR PANELS, MORRIS TEN (SERIES "M")—*continued*

Description	*No. Reqd.*	*Part No.*	*Identity No.*
Drip moulding (front) O/S		105142	
,, ,, (front) N/S		105143	46
,, ,, (roof) O/S		105482	—
,, ,, (roof) N/S		105483	47
Side panel O/S		105924	—
,, ,, N/S		105925	48
Wheel-arch filler O/S		105930	—
,, ,, ,, N/S		105931	49
Lower panel shroud assembly O/S		105978	—
,, ,, ,, ,, N/S		105979	50
Front-door assembly O/S		105926	—
,, ,, ,, N/S		105927	51
Rear-door assembly O/S		105928	—
,, ,, ,, N/S		105929	52
Side-header reinforcement O/S		105982	—
,, ,, ,, N/S		105983	53
Sliding-roof channel assembly		105332	54
Sliding-lid assembly		105418	55
Roof panel (S.H. Saloon)		105338	56
,, ,, (F.H. Saloon)		105913	—
Parcel shelf		105130	57
Quarter-light reinforcement O/S		105478	58
,, ,, ,, N/S		105479	—
Trunk-panel assembly		105111	59
Trunk-opening reinforcement		105312	60
Trunk-floor side support O/S		105496	—
,, ,, ,, ,, N/S		105497	61
Trunk-floor rear support		105314	—
Trunk-lid assembly		105932	62
Spare-wheel clip		83954	63
Spare-wheel lid assembly		105101	64

which is spot welded to the rear quarter panels, the joints being hidden by plumber's solder.

At the scuttle the assembly is completed by welding the dashpan in position, and then the windscreen panel, which includes the top panel for the scuttle.

The roof sub-assembly, consisting of the sliding-head channel assembly, is welded to the windscreen assembly at the forward end and to the body side assemblies on each side, the actual roof panel incorporating the rear light being flash welded to the windscreen panel and spot welded to the body side assemblies and trunk panel.

The First Step on Repairing

When undertaking a repair it is first necessary to straighten the bent or distorted portions of the body structure, using the body-straightening

jack and special end pads as indicated in the section dealing with steel-bodywork repair in general.

If your standard end pads do not fit snugly into the contour of the body of the Series "M" Morris Ten, it is advisable to prepare suitable end pads in hardwood in order to avoid the possibility of damage to the good portions of the body.

Remember, also, that it is essential to anchor the foot of the jack against a portion of the body which cannot easily be distorted. For instance, if you want to straighten out a bent door-post do *not* anchor the foot of the jack to the centre of the opposite door-post, but use it diagonally with its foot leaning against the base of the opposite pillar or some similar rigid portion of the structure. The body jack is a powerful tool and must be used with intelligence if the best results are to be obtained.

Remember, also, that this type of construction lends itself to a considerable amount of straightening, and that parts which often look past salvage can frequently be rendered quite serviceable by careful straightening and beating.

Having failed to straighten out the damage successfully, consideration may be given to replacement of the damaged portion, and a careful decision made as to where the damaged part will be cut away.

Whenever possible it is always advisable to stagger the joints where two or more panels are adjacent to each other.

Only whole replacement panels as indicated in the accompanying illustrations are supplied by Morris Motors Limited, so that you may have to order more material than you actually require. When the new panel arrives, carefully cut it to match up with the existing portion of the body, retaining any pieces left over as they may be of use in later repairs undertaken.

Checking Alignment

Owing to the special construction the procedure necessary for checking the alignment of the body either before or after repair is slightly more involved than on the orthodox chassis owing to the presence of the body structure.

A good method is to carefully plot the position of the essential portions of the body on a smooth and level floor.

It is, of course, essential that the chassis should lie perfectly level during this operation, and to ensure this a spirit-level should be placed on the flat surfaces at the front and rear ends of the sub-frame, adjusting the level accordingly. If the axles and wheels are in position the level can be adjusted by a suitable manipulation of the tyre pressures.

The centre line of the sub-frame can be marked out on the floor by the use of a plumb-bob and line, and the position of the spring-anchorage bolt-holes and shackle-bolt holes can then also be plotted on the floor, remembering to use the same side of the lugs in all cases.

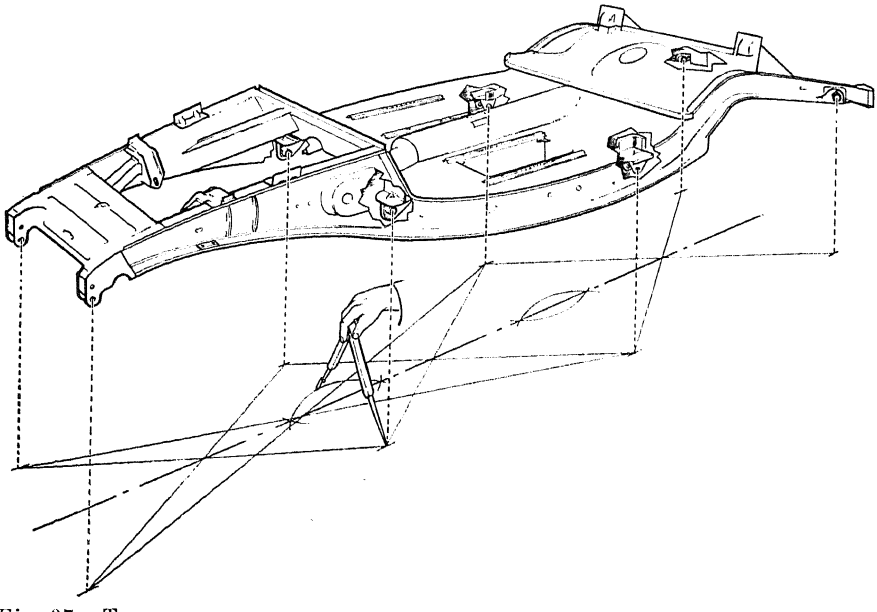


Fig. 37.—THE METHOD OF CHECKING THE ALIGNMENT OF THE FRAME RECOMMENDED BY MORRIS MOTORS LTD.

Verticals are dropped from the spring mountings with a plumb-bob on to the floor and centre lines and diagonals drawn.

Each pair of spring-bolt-hole marks is then engaged by a compass and arcs drawn at the centre of the chassis to locate the exact centre between them. A chalk line is then employed to draw a centre line on the floor, the line being held taut and coinciding with the extreme markings at the front and rear ends of the chassis. A chalk mark is then made on the floor by the usual method of raising the line a few inches and letting it spring back into position.

If all the remaining centre-line marks coincide with the chalk-line marking, indication is clearly given that this item of alignment of the frame is satisfactory.

A further check should, however, be applied by drawing diagonal chalk lines joining the various spring-bolt locations, duplicating them from each side so that they intersect on the body centre line. If their intersection joint does not lie on the centre line it indicates that the frame alignment between these joints is defective, and careful consideration, and measurements in accordance with the drawings herewith, will show in which direction the frame must be set to rectify matters.

Before rectifying frame misalignment make sure that you are applying the rectifying force at the right point and to the right extent.

In the case of a severe accident involving the front end of the car, the

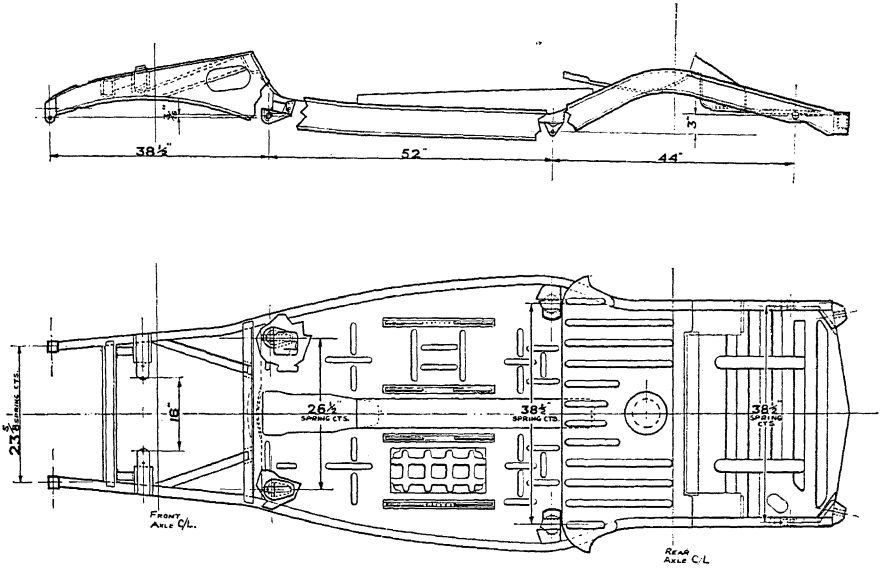


Fig. 38.—THE PRINCIPAL DIMENSIONS OF THE MORRIS TEN (SERIES "M") FRAME

alignment of the engine mounting brackets may be affected, in which case the use of a special alignment jig is recommended. Such a jig is obtainable from the Service Parts Department of Morris Motors Ltd., Cowley, Oxford. This jig is located to the front spring-anchorage brackets by means of a fixed mandrel, and to the front spring-shackle bracket by the screwed shackle pin, and therefore also serves as a check on the correct position of the front spring shackle and anchorage bolts.

A detachable plate is provided with the jig for checking up the engine-bracket holes, having a dowel and hole at one end for location to the engine bracket with a setscrew, and an extension to the other end which engages a slot in the jig. Provided the detachable plate can be assembled with its end engaging the slot in the jig it may be taken that the engine brackets are in proper alignment in relation to the front spring brackets.

Breaking Welded Joints

Having carefully examined the damage, and decided, in cases of extensive damage, where the new panel units will be joined, the next step is to remove the damaged portions.

Most of the parts are joined together by spot welding and this method precludes parting of the joints with a cold chisel and hammer, as this tends to distort and tear the panel. The only satisfactory way to separate spot-welded joints is to drill out the centre of each spot weld with a $\frac{3}{16}$-in.

or $\frac{1}{4}$-in. drill. Actually it is not necessary to drill right through the two panels ; if the point of the drill just begins to break through the second panel it will be sufficient, and the two panels can then be separated quite easily by inserting a sharp cold chisel between the joint and tapping it lightly with a hammer.

Where the position of the original spot welds is hidden by paint a suitable liquid stripper will have to be applied to reveal the welds, which are then easily located by the discoloration of the metal.

Gas-welded joints are best separated by cutting with a hacksaw whenever possible. If the location of the weld is awkwardly placed a sharp cold chisel will have to be employed, but it is not so satisfactory as a hacksaw.

Several of the lap joints in the body, notably those at the junction of the windscreen panel with the side panel, and the trunk panel with the side panel, are sunk below the level of the surrounding panel, and the channel thus formed is filled with plumber's solder to provide an unbroken surface for the paintwork.

To expose the joint it is necessary to melt the solder and wipe it away, using a blow-lamp or oxy-acetylene blow-pipe to obtain the necessary heat.

When the solder has been wiped away the joint can be broken by drilling out the spot welds, as already detailed.

At its forward end the roof panel is butt welded to the windscreen panel, and when required this joint can be broken by the use of a cold chisel and hammer, directing the blows of the hammer towards the panel not required. In case of difficulty in breaking this joint a little heat may be applied to the weld with the oxy-acetylene blow-pipe, to soften the fused edges of the weld, or alternatively the joint may be cut with a hacksaw.

When remaking spot welds the two panels should be welded, through the holes drilled for separating the panels, by gas welding, in the manner described in the section on the general repair of all-steel bodies.

Replacement of Panels

Although in the majority of cases it will be found possible to rectify the original panels if care is taken, in certain cases of extensive damage it may be found more economical to cut away the damaged portions and employ the replacement panels available.

It will, however, usually be found that the damage is localised and that a complete replacement panel will not be necessary. In most cases the damaged portion can easily be cut away and a replacement cut from a corresponding panel and fixed in position by gas welding.

For instance, should a door pillar be badly damaged it would obviously be uneconomical to replace the whole side panel. The correct procedure would be to cut away the pillar and replace it with a pillar cut from a

replacement side panel. This would of course mean buying a complete replacement side panel just the same, but it is more than likely that the remaining portions left over will be required for another repair job at a later date.

It is to be noted that Morris Motors will sell only complete panels, and will not divide them up.

Special Features

Apart from the monopiece construction the Morris Series "M" Ten employs certain other features which are not common to other cars.

The door assemblies, for instance, are made up entirely from steel pressings, and have no wood in their construction, while the front-door window lift is cable-operated.

Since the doors are of all-steel construction they will not warp under the action of the weather, and the only thing which will interfere with their fit is accidental damage.

The methods of regulating the proper shutting of the door are exactly as indicated in the section dealing with the general repair of all-steel bodies.

Removing Front-door Glass

First remove the bakelite window frame, which is held in position on the door by eight chromium-plated screws of the self-tapping type. This will enable you to remove the door trim panel after withdrawing the window regulator and door-lock handles (which are held on to their spindles by cheese-headed screws and spring washers), slackening the screws holding the door pin plate to the door frame, detaching the finishing plate for the pin plate, and removing the eight self-tapping screws which attach the door trim panel to the door frame.

Removal of the trim panel reveals the window-winding mechanism and permits the removal of the inner glass draught-excluder, which is held in position by four self-tapping screws.

It will be seen that the glass channel is attached to the operating cables by two clamps. Unscrew the two cheese-headed screws in each clamp and extract the rubber stop upon which the glass channel rests when the glass is in the "down" position.

The outer draught strip for the door glass is then removed from the door frame by prising out the four spring clips which form part of it.

The front guide channel must now be detached from the door frame by unscrewing the cheese-headed screw at the top end, and the hexagon-headed setscrew at the bottom end, which are located in the depressions of the inner door panel.

The glass should then be raised and turned towards the front of the car so that the top edge of the glass faces forward, when no difficulty will be encountered in removing it.



Fig. 39.—REMOVING FRONT-DOOR GLASS

Showing the manner in which the front-door glass is raised and rotated forward for removal. (*Morris Motors Ltd.*)

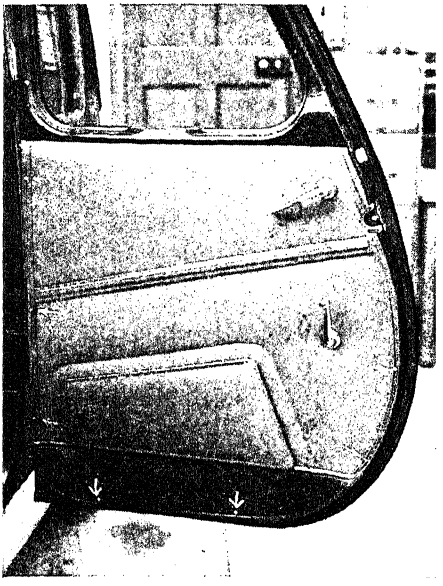


Fig. 40.—FRONT-DOOR TRIM

Here are shown the series of screws which attach the front-door trim panel to the door frame. (*Morris Motors Ltd.*)

The window-felt guide channel is fixed to the door frame by seven countersunk-headed self-tapping screws, and cemented to both front and rear metal channels with "Bostick." Once the glass is removed this guide channel can be removed quite easily when necessary.

Front-window Regulators

These are of the cable-actuated type, and provision has been made for adjustment of the cable tension, when necessary, by mounting the two lower pulley spindles in elongated holes in the door-frame panel.

Adjustment is effected by slackening the pulley spindle nuts and removing the spindles in the required direction. There is enough adjustment provided to enable fresh cables to be introduced without the necessity for removing the pulleys.

The cables are actuated by a chain passing over a sprocket attached to the regulator spindle by a $\frac{3}{16}$-in. nut. This nut can be reached by introducing a $\frac{3}{16}$-in. spanner behind the inner door panel.

Replacing the Front-door Glass

First of all the regulator chain should be moved so that it extends as far as possible towards the top of the door.

The glass, complete with its channel, is then inserted in the door frame and lowered so that it rests squarely on its rubber stop.

The glass channel is then attached to the operating cables by replacing the fixing clamps and their screws.

Following this the remaining components may be replaced in the reverse order to their removal.

Removing Front-door Locks

Remove the outside door handle by unscrewing the two plated screws which attach the escutcheon plate to the door panel. In the case of the offside handle, which incorporates the private lock, this is in addition secured in position by countersunk-headed screws inserted in the inner end of the spindle, and this must naturally be removed before the handle can be withdrawn.

Raise the glass to the fullest extent and release the front guide channel from the inner panel as already described.

Removal of the four lock-retaining screws, two on the door shut face, and two on the inner door panel, will enable the lock to be withdrawn.

The Door Checks

The door checks are of the metal type, consisting of a metal check arm passing though the door frame and a resilient buffer to which it is located by a metal collar which engages slots in the end of the check arm.

Access to the door checks is obtained by removing the door trim panel.

If it is required to remove the door-check assembly this is carried out by extracting the rivet attaching the check arm to the lug on the door pillar, and withdrawing the check assembly from inside the door frame.

When replacement parts are fitted the door check components should be replaced in the following sequence :

The buffer should be

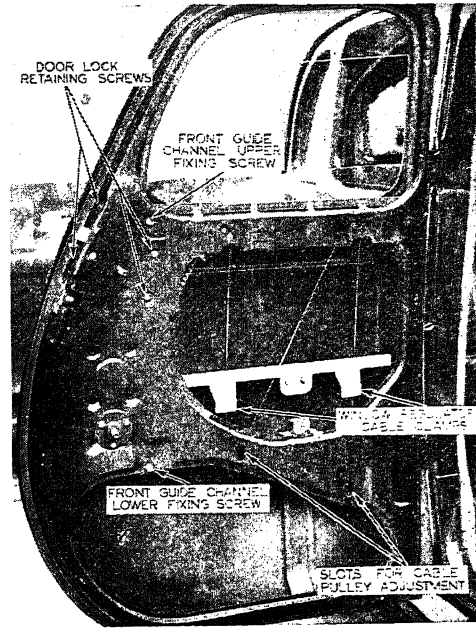


Fig. 41.—THE LOCATION OF SOME OF THE ATTACHMENT SCREWS FOR THE VARIOUS DOOR FITTINGS AND THE CABLE-PULLEY ADJUSTING SLOTS. (*Morris Motors Ltd.*)

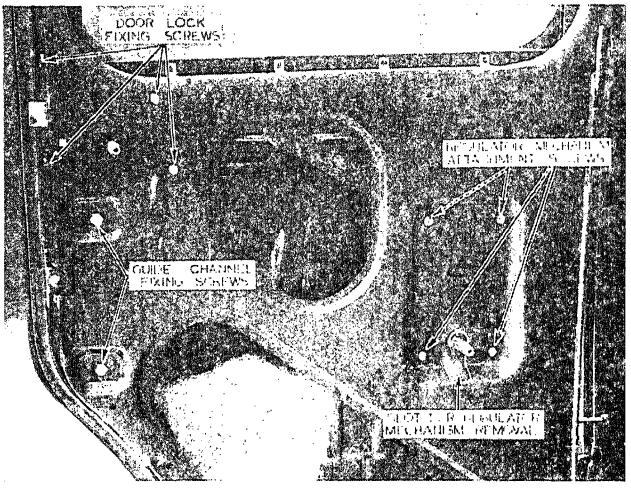


Fig. 42.—THE POSITION OF THE SCREWS ATTACHING THE DOOR LOCK, WINDOW REGULATOR, AND GUIDE CHANNEL ON THE REAR DOOR

Also shown is the slot required for removal of the regulator mechanism. (*Morris Motors Ltd.*)

threaded on to the slotted end of the check arm—small end first.

The tongued and slotted retaining washer should then be inserted in position on the end of the check arm, hollow side outwards.

The slotted rubber stop-washer should next be slid into position, followed by the slotted metal retaining washers.

Care should be taken to ensure that the front and rear doors do not meet when both are opened to their fullest extent. The maximum door opening can be adjusted by inserting the slotted retaining washer in the appropriate slot in the check arm, after which it can be locked in position by bending down the two ears of the retaining washer into engagement with it.

Door-sealing Rubber Strip

The rubber weather-sealing strip which runs round the front and top edge of the doors can easily be removed for replacement by pulling it out with a pair of pliers or similar suitable tool.

The ends of the channels holding the strip in position are lightly peened over to ensure that the rubber strip does not creep out of the channel. Before replacing the rubber strip prise out the channel ends to their normal dimensions.

When fitting a new rubber sealing strip insert one side into the metal retaining channel, and then press in the other side into the opposite recess of the channel with a blunt screwdriver, using a sliding motion.

When the rubber sealing strip is properly inserted in its retaining channel, lightly peen the ends of the channel to make sure it remains in this position.

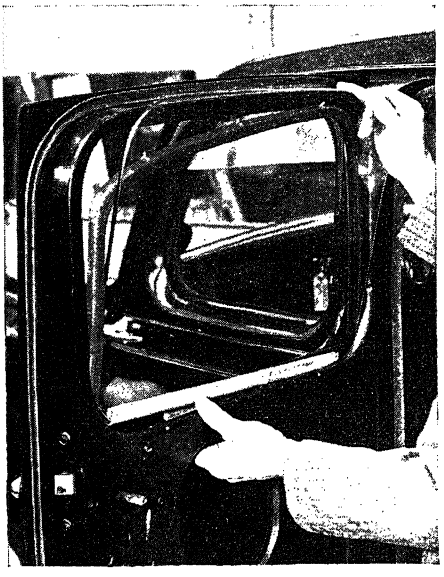


Fig. 43.—WITHDRAWING REAR DOOR GLASS
Raise glass upwards and tilt it inwards, after removing the necessary components. (*Morris Motors, Ltd.*)



Fig. 44.—THE METHOD OF WITHDRAWING THE RUBBER ROOF DRAIN PIPES (*Morris Motors, Ltd.*)

Rear-door Window Regulator

The window regulators on the rear doors are of the rack-and-pinion type, and access to them is obtained by removing the door trim panel in the same way as on the front doors.

The regulator mechanism is attached to the inner door panel by four cheese-headed screws at each corner of the panel recess. Removal of these screws and their spring washers will enable the regulator arm to be detached from the glass channel, and the regulator assembly withdrawn.

A few of the early models of this series possessed a circular hole in the inner door panel through which the regulator spindle passed. In such cases it is necessary to elongate this hole downwards to the edge of the panel depression in order to permit withdrawal of the regulating mechanism.

Removing Rear-door Glasses

To withdraw the glass from the door frame it is necessary to remove the bakelite surround and door trim panel as already described, release the regulator from the inner door panel, and disconnect the regulator arm from the glass channel. It is, however, not necessary to remove the regulator entirely from the door frame.

If the felt guide channel is detached from the door frame by removing the eight countersunk attachment screws, the glass can be withdrawn by raising it upwards, tilting it inwards at the same time.

The felt of the guide channel is secured in its metal retainer by "Bostick," and it can be withdrawn for replacement after extraction of the door glass.

The rear metal guide channel is retained in position by two $\frac{3}{16}$-in. hexagon-headed screws and spring washers.

Removing Rear-door Locks

Before removing the lock of the rear door it is first necessary to remove the door glass and metal channel as already described, and also the door handle by removing the two escutcheon screws. It is then an easy matter to remove the lock assembly after unscrewing the two screws on the shut edge of the door and the two screws on the inner door panel, which locate it in position.

The Sliding-head Assembly

To remove the sliding-head assembly open the sliding panel approximately halfway and remove the cheese-headed screws which attach the two guide plates to the two forward corners of the sliding panel, levering the guide plates outwards to disengage them from the runners.

The sliding panel assembly can now be drawn forwards and upwards until it is clear of the body.

If the sliding panel is not closing flush, or is fouling the roof panel, its position may be adjusted when it is removed by setting the spring guides at the rear end.

To replace the roof assembly see that the centralising rod attached to the rear of the framework coincides with the slot in the rear face, and that the felt guides at the rear enter the channel of the roof runners at each side. The roof should then be pushed rearwards, lowering the front at the same time, until the assembly is in position.

The front end guides may now be replaced in engagement with the runners and their retaining screws replaced.

Should the sliding panel trimming need attention, it should be remembered that it is attached by tacks to the front and sides of the panel on to wood fillets, but that it is held by adhesive only at the rear end.

Roof Drain-pipes

Rain-water from the roof is drained away by concealed ducts which discharge the water below the body. These ducts are in the form of rubber tubes passing down the "A" posts and "D" posts, and are attached to the roof-water ducts by hose clips.

They can be withdrawn for cleaning or replacement by detaching the roof trimming for a distance of approximately 12 in. on either side of the

body post, which will give access to the hose clip, which can then be released.

In order to ensure that the drain tube can be replaced without trouble it is advisable to attach an ample length of wire to the lower end, which can be used to draw the tube back after it has been given attention.

When the hose clip has been released, the tube end can be released from the roof duct and withdrawn by drawing it into the car.

When the lower end comes through do not forget to detach the draw wire, so that it remains in place for the subsequent replacement.

Removing the Windscreen

Open the windscreen some 3 or 4 in., and release the windscreen-adjustment chain from its attachment to the windscreen by removing the cheese-headed attachment screw. The chain can now be screwed back into its housing.

From inside the car remove the $\frac{1}{4}$-in. setscrew and plated adjusting screw with raised head from each of the windscreen hinges. This will enable you to remove the screen with the help of an assistant.

Replacing the Windscreen

The windscreen is replaced in the reverse order to its removal, but it must be remembered that the $\frac{1}{4}$-in. hexagon lockscrews must not be tightened up until the screen has been correctly adjusted, by means of the adjusting screws, so that the rubber water-seal is making proper contact all round the screen panel. This adjustment should, of course, be carried out with the screen fully closed, and when properly carried out the adjustment should be locked by tightening up the $\frac{1}{4}$-in. hexagon lock-screws.

Removal of the Boot Lid

Remove the spare wheel and detach the floor of the luggage compartment by withdrawing the six countersunk screws, which are

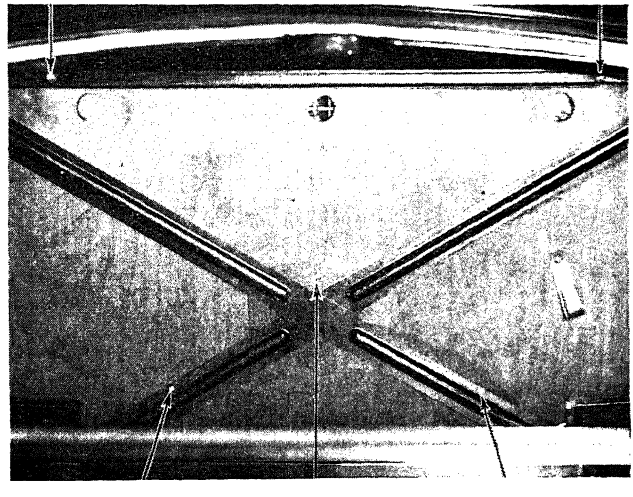


Fig. 45.—THE POSITION OF THE REAR SEAT SQUAB FIXING SCREWS (*Morris Motors, Ltd.*)

located just behind the seat squab reinforcement, and the eight countersunk screws with nuts and washers situated at the rear just inside the boot opening. Access to the nuts and spring washers is obtained through the spare-wheel compartment.

Release the hinges for the lid from the body by unscrewing the retaining screws, and fold the hinge arms against the inner face of the lid.

Remove the lock handle from the lid by unscrewing the two screws which attach the handle escutcheon in position, and the screw on the inside which passes into the spindle of the handle.

With the help of an assistant slide the lid carefully into the spare-wheel compartment, raising the rear end to clear the spare-wheel brackets and turning it sideways so that it can be withdrawn, taking care all the while not to damage the paintwork. When refitting the lid, use a tapered mandrel to line up the box nuts for the hinge screws and the screws at the forward end of the boot floor.

Removing Roof Trimming

Detach the roof-lamp switch by unscrewing its two fixing screws, and disconnect the two leads from the terminals at the back.

Remove the roof-lamp glass by withdrawing the retaining spring, thus exposing the three wood-screws, removal of which will enable the roof-lamp to be withdrawn after the leads have been disconnected. The mauve-coloured lead is connected to the insulated terminal.

Remove the bakelite surrounds from both the rear-quarter lights by removing their attachment screws, noting that two of the screws are longer than the rest and locate the surround to the " D " post. Remove, also, the rear-light surround, which is attached by ten screws.

Extract the tacks from the " Jubilee " banding finishing the edges of the roof lining, including that at the sliding-head opening and the windscreen top rail, and then extract the remaining tacks holding the lining.

This leaves the trimming supported only by the two support rails at the domed portion of the roof at the rear, and it is finally released by removing the eight wood-screws which hold the support rail in position, permitting its withdrawal complete with support rail.

The Seats

The front seats are released by removing the cheese-head stop-screw from the forward end of each seat runner. Raising the seat catch then enables the seat to be pulled forward clear of the runners.

In the case of the rear seat, the seat squab is attached to the rear of the body at five points, access to which is achieved through the luggage boot.

There are two attachment nuts located on the rail just below the rear light, and three countersunk screws, one passing through the rectangular stiffening plate in the centre of the " X " bracing member and one approximately halfway down each of the lower members of the " X " brace.

OVERHAUL OF 7-H.P. AND 10-H.P. AUSTIN REAR AXLES

By W. W. MEAD, M.I.M.T.

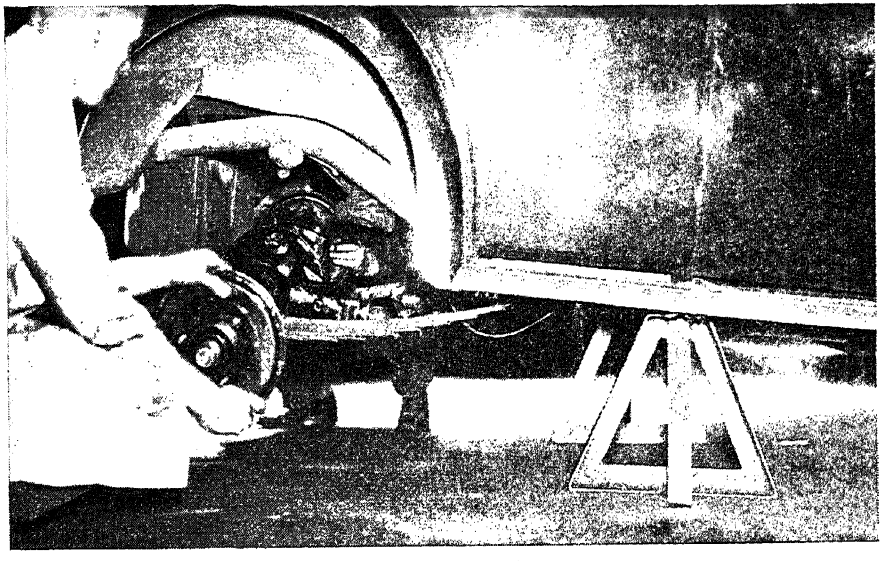


Fig. 1.—Removal of Axle

Showing position for the trestles and the axle being passed out from the side of the car.

10-H.P. MODEL

IN dealing with rear-axle repair the same procedure should be followed as with other units. Test and ascertain from an outside diagnosis, if possible, the cause of trouble. In the case of complete failure, of course, the trouble will be obvious when the axle is dismantled, but the complaint is generally of undue noise. Axle noises can be divided into three classes: (1) Humming or whining, (2) Roughness, (3) Knocking. Take the complaints in order.

Humming or Whining

This is usually caused by an incorrectly meshed crown-wheel and pinion. They can both be adjusted independently, and this is invaluable when fitting a new pair. But if an axle has run long enough for the wheels to have become mated, adjustments are of little use, and it is very

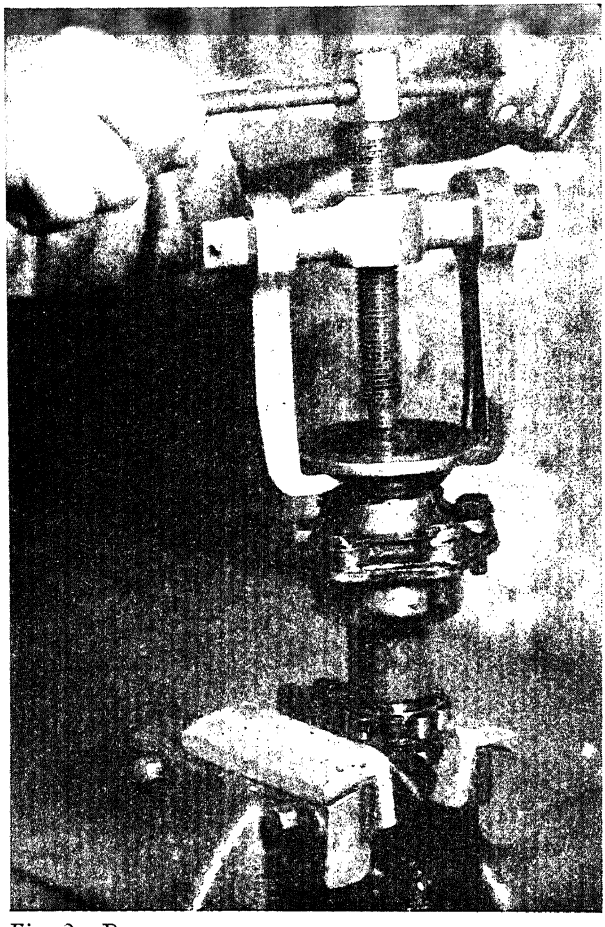


Fig. 2.—DRAWING THE BEVEL SHAFT WITH THE AUSTIN UNIVERSAL EXTRACTOR

doubtful if an improvement can be made by the use of them. During the early life of the car the insertion or removal of a shim or shims at the bevel pinion may quieten a noisy axle, but adjustments cannot be made to the crown-wheel adjusting collars whilst the axle is under the car because the petrol tank is in the way. The only alternative to adjustment is the removal and dismantling of the unit and refloating of the crown and bevel. It may even be found necessary to replace these parts.

Roughness

Roughness is usually caused by defective ball races. Before dismantling the axle, remove the bevel pinion and examine the races on the assembly. If any of these are defective they should be replaced and an effort made to adjust the position of the bevel to the crown-wheel with shims.

Knocking

This is usually caused by a chipped tooth or teeth of the crown-wheel or bevel pinion. Replacement is of course necessary. A chipped ball or roller in a race can cause intermittent knocking. Having decided dismantling is necessary, proceed in the following order :

Removal of Axle

Jack up the car under the chassis frame just forward of the rear axle. It is best to raise the car on a high-lift jack from the centre of the rear axle and let it down again on trestles in the position mentioned. Now disconnect the propeller shaft by taking out the bolts holding it to the bevel-pinion driving flanges. Remove the rear road wheels. Disconnect the shock absorbers where connected to the axle case and push them up out of the way. Take out the pin holding the brake cable to the pivot near the centre of the axle case. Remove the spring clips which hold the axle to the road springs ; now remove the axle by passing it out sideways from the car between the rear spring and the chassis frame (Fig. 1). (Take care of the wood packings.)

Dismantling

Holding the axle with the bevel gear facing upward, take out the bevel drive by removing the six setscrews holding it to the axle case. (Don't lose the shims.) The outer track of the roller race will remain behind in the case, and can be knocked out later. Turn the axle over and let the lubricant drain out. Hold the gear in the vice between lead clamps and knock up the locking washer of the driving-flange nut and remove the nut with a box spanner. Now draw off the flange with a claw driver (Fig. 2).

The bearing cap, housing, oil seal, compound race, distance-piece, and centre track and roller of the race will come off by banging the screwed end of the bevel shaft on a wooden or lead block.

Hold the axle casing in the vice horizontally. Take off the brake drums, after removing the two countersunk screws

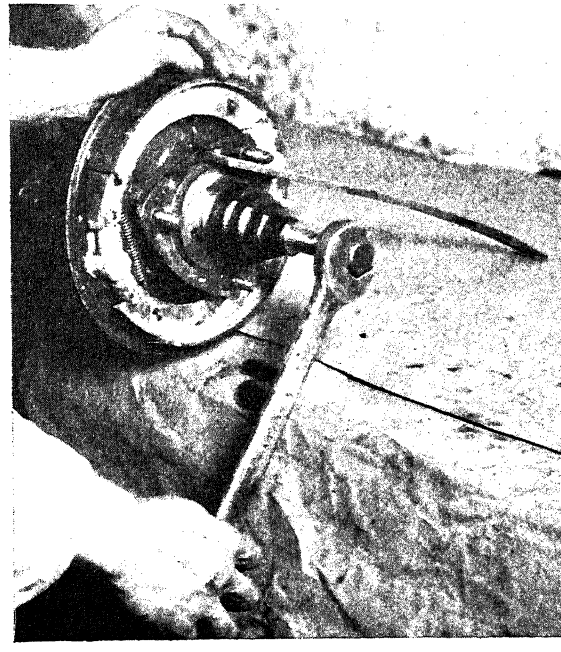


Fig. 3.—DRAWING OFF THE HUB

Showing the lever in position to prevent the hub turning.

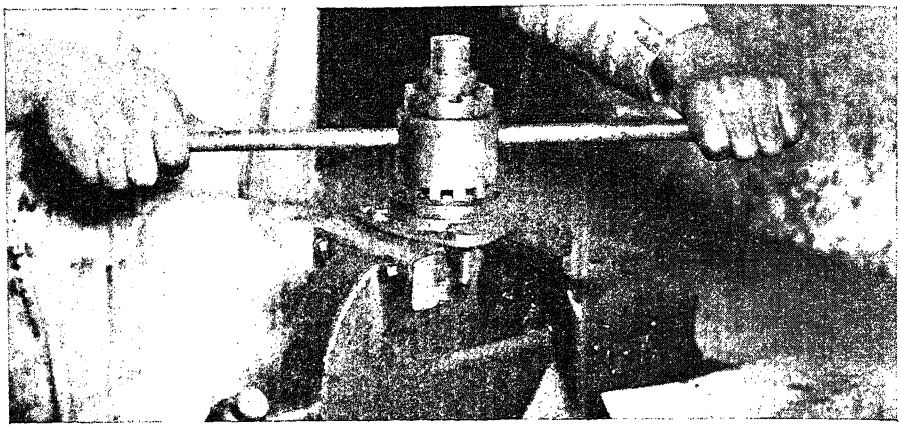


Fig. 4.—THE SPECIAL SPANNER FOR FITTING OR REMOVING THE HUB RACE CLAMPING NUTS

which hold them to the hubs. Take out the axle shaft split-pins and nuts. By placing a lever between two of the studs and letting the end rest on the bench the hubs can be held whilst the nuts are loosened (Fig. 3). Now draw off both hubs with a hub drawer. If the brakes are not to be relined mark their position with chalk, also the drums.

The hub roller race is held in position by castellated locking ring. This is in turn locked in position by a locking washer held by a setscrew. A special spanner is made by the manufacturers for removing this ring (Fig. 4). It can be loosened by a hammer and drift, but care should be taken not to mutilate it. The inner track will remain on the end of the axle casing, and can be removed later if necessary.

Remove the setscrews holding the two halves of the axle case together. These are fitted with spring washers. Now take off the nearside or small half of the casing. Then draw out the cross-shafts complete with the differential casing and crown-wheel. Remove the bolts holding the two halves together. Remove the cross-shafts, the differential wheels, and centre.

Going back to the offside axle case, remove the setscrew holding the outer track of the bevel-pinion roller race and knock the track out. Carefully knock the differential roller races off the cases and then thoroughly wash all parts.

Examining Parts for Wear

After all the parts have been washed the races should have a final clean in perfectly clean petrol and then be examined for wear; use a magnifying glass to examine the rollers or balls.

Test the differential thrust races by holding them in a vice, with the

faces marked "thrust" together. Try two feelers at once between the outer tracks. If larger than ·002 in. passes, renew them.

The roller and compound races should be examined for wear or roughness and renewed if necessary. Look to the bores of all races and make sure they have not revolved on their shafts and worn. Try the hub roller races on their inner tracks; do not remove the inner tracks from the cases unless they need renewing, because they are difficult to punch off and are likely to be injured during the process.

A word might be said here regarding the earlier type of 10-h.p. car, when ball races were fitted to the hubs. It has been known for the inner track of these to revolve on the casing and wear a recess in it. The remedy is to expand the end of the case if the wear is not more than ·010 in. If more, it is possible to obtain races from the manufacturers ·075 in. undersize in the bore. The case should be turned down to fit.

Examine the bevel-shaft distance-piece and make sure this has been clamped tight. If there is any sign of the races having moved against the ends, renew it.

All axle cases, cross-shafts, and the differential cases should be tested for truth. Any excessive end float of the cross-shafts should be taken up by fitting new bushes to the differential cases. A running clearance of ·002 in. should be allowed between the end of the cross-shaft pinions and the differential centre.

Carefully examine the bevel pinion; if there is any sign of picking-up, namely if the teeth are rough and look as if they have tried to seize up to the crown-wheel teeth, they should be renewed.

Now examine the crown-wheel teeth: this often shows more evidence of noise than the bevel gear; look along the teeth for any lines or indentations or signs of wear taking place in a series of flat surfaces, or wear taking place more at one end of the teeth than at the other. If any of

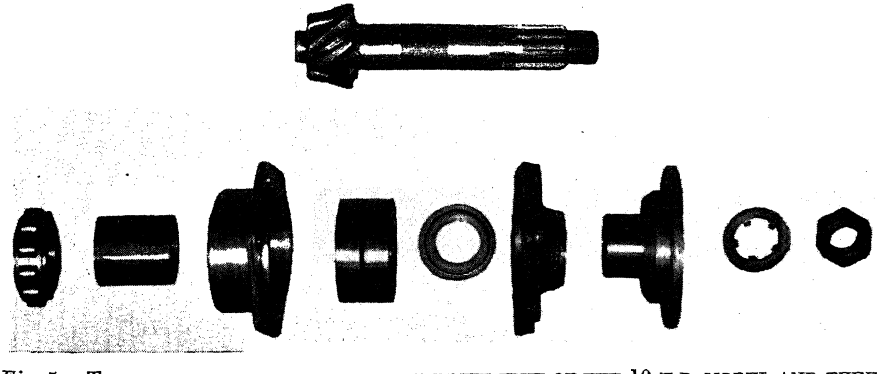


Fig. 5.—THE PARTS COMPRISING THE BEVEL-DRIVE UNIT OF THE 10-H.P. MODEL AND THEIR ORDER OF ASSEMBLY



Fig. 6.—THE SPECIAL CROWN AND BEVEL-MESHING TOOL IN USE

these conditions show they should be renewed. It is possible to obtain crown-wheels and bevels only in pairs. They are ground in pairs and never parted. They are each marked with a number, and it is always wise to check up when buying a new pair to see that the numbers match.

Take this opportunity of examining the Girling-brake housings. Clean and repack them with the special grease necessary, namely Keenol KG 20.

Assembling the Axle

Having decided on the new material necessary, the axle can be built up. Start with the bevel drive. The order of assembly is first the roller race, then the distance-piece, next the compound race assembled in the housing, now the bearing cap—not forgetting to fit a new oil seal, lastly the bevel-driving flange (Fig. 5). Use a new locking washer. The whole assembly is held by the bevel-shaft nut, and care must be taken to ensure the nut is tightened right home before the lockwasher is turned over. Use a box spanner and a long tommy bar. Give the housing a sharp blow with a mallet to ensure the bearing has gone right home before the final tightening up.

Correct Meshing of Wheel and Pinion

The proper way of ensuring the correct meshing of the crown-wheel and bevel pinion is to assemble them with the help of the gauge made for

the purpose by the manufacturers (Fig. 6). The gauge locates in the offside axle-case bearing housing, and is free to revolve. The periphery of the gauge is eccentric and is marked in one-thousandths of an inch. On both the crown-wheel and pinion, figures are etched, as example $\frac{3}{2}\frac{9}{5}\frac{4}{3}\frac{2}{5}$. As already stated, the number should always be the same on both parts. The bottom figure is the one to set the gauge to. The necessary number of shims should be fitted between the bevel housing and the axle case, so that when the six setscrews are tightened down the gauge will just touch the end of the bevel gear with the line (in this case 25) at the centre of the gear. This method ensures that the pair of gears run in exactly the same relative position as that in which they were ground together when made.

Without this tool one has to use the " hit and miss " method of getting a full meshing tooth and the right amount of slack by adding and removing shims until a quiet running position is obtained. When the bevel drive is in position, refit the roller-race locking screw.

Assembling Differential Assembly

Now turn to the differential assembly. If a new crown-wheel has been fitted, bolt the two halves of the differential cases together without

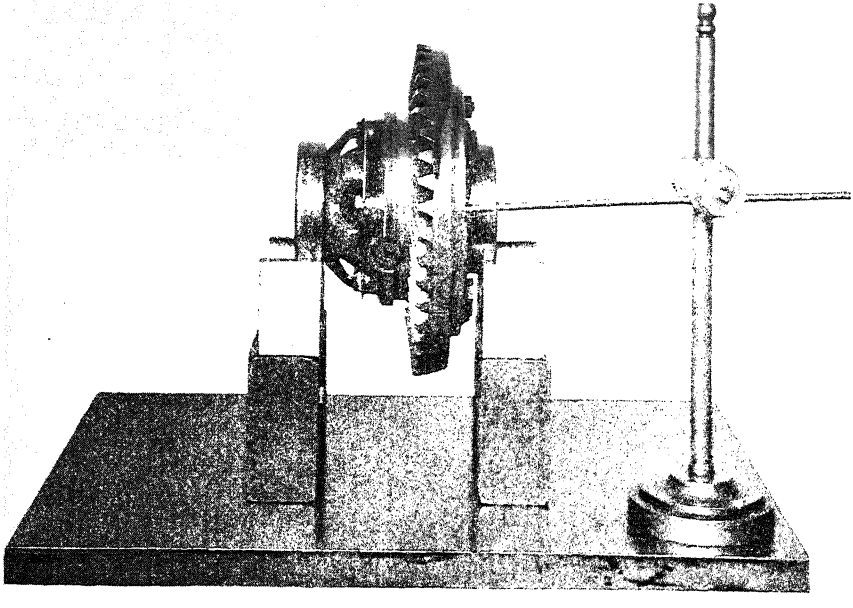


Fig. 7.—TESTING THE CROWN-WHEEL FOR TRUTH AFTER BOLTING IT TO THE DIFFERENTIAL CASE

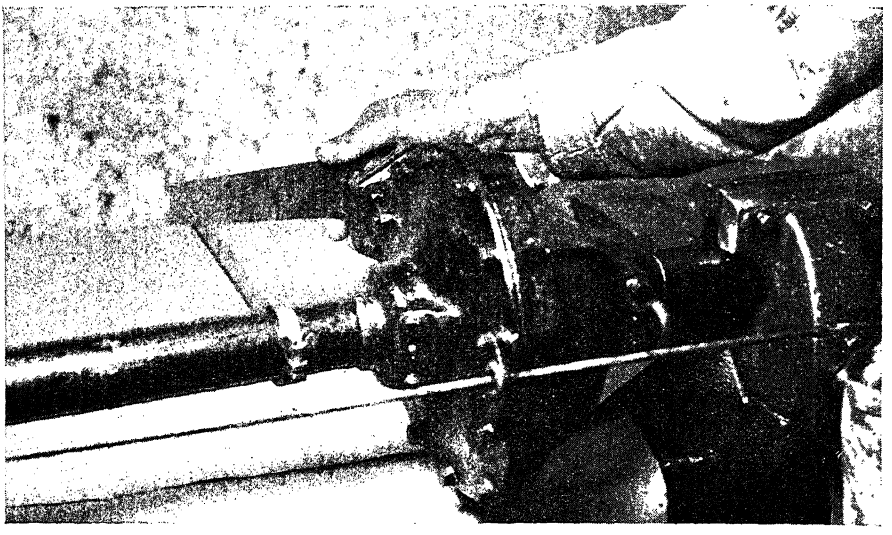


Fig. 8.—TESTING THE BACKLASH BETWEEN THE CROWN-WHEEL AND BEVEL

the centre. Tap on the thrust races, making sure the side marked "thrust" is outward, and placing the whole on a pair of V blocks, revolve the case and test the crown-wheel with a scribing block for truth (Fig. 7). Now open up the case and reassemble with the cross-shafts, differential wheels, and centre. Smear a coating of oil on all parts as they are assembled. Take care the bolts used are in good condition, and the threads not stretched. Use new lock washers. The differential-case bolts are of a special high-tensile steel, and should be obtained only from the manufacturers or their agents. Hold the offside axle case in the vice with the centre upward. Drop the assembly, complete with cross-shafts, into the case. Use a new brown-paper washer and fit the nearside case. Tighten the setscrews of the two halves evenly, and finally adjust the collars to control the backlash and thrust of the differential assembly.

Adjusting Differential Assembly

The method of checking this is to fit a bar of metal or wood across the bevel-driving flange. Make a mark on the bar 7 in. from the centre. At this mark the backlash should be $\frac{1}{16}$ in. (Fig. 8). Having adjusted the backlash take up all end thrust with the nearside adjusting collar.

Before fitting the hubs examine the brake shoes, and if the liners are worn fit relined shoes. If the wear is not severe it will no doubt be found that one liner on each hub is worn more than the other. This is on the trailing shoe. Change them over. On the type of shoe where the springs fit direct into the shoe the top can be placed to the bottom on the same

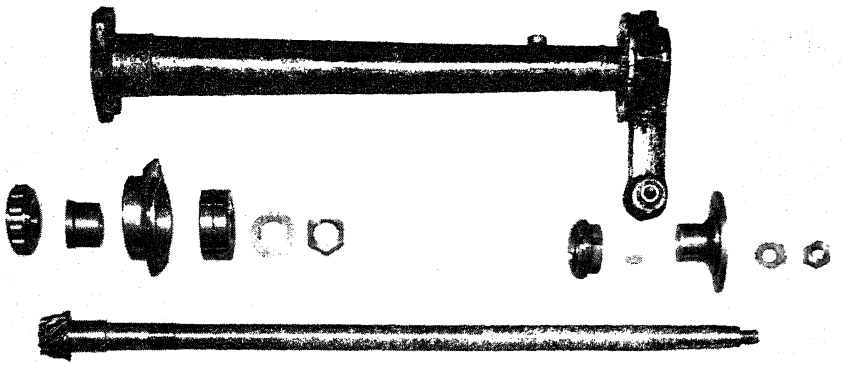


Fig. 9.—THE BEVEL SHAFT AND TORQUE TUBE OF THE 7-H.P. MODELS
Showing the order of assembly. The small ball race is in the front end of the torque tube.

hub, but on the type where the springs are anchored on pins it will be necessary to change the shoes to the opposite hub, making the bottom shoe of one side become the upper shoe of the other.

When replacing the hubs use new oil-sealing washers. When filling the axle place it in the same relative position as it will be on the car, to ensure it will not be over-filled. Bear in mind that a high-press lubricant should be used—one of the grades recommended by the manufacturers.

The refitting of the axle is a simple operation, carried out in reverse to removal.

7-H.P. AND BIG 7-H.P. MODELS

The construction of 7-h.p. and Big 7-h.p. rear axles is the same, but they are somewhat different from the 10-h.p. One of the differences is in the arrangement of the bevel drive, which consists of a long shaft housed in a torque tube. The forward end of this tube is spherical and fits into a housing with freedom to move, the whole housing being anchored to a silent-block bush which fits into a bracket bolted to the cross-member of the chassis frame. The shaft revolves on three bearings, one roller and 1 compound thrust-race at the bevel end, and a ball race at the front end. A left-hand threaded nut and tongued locking washer clamps the rear-end races and distance-piece (Fig. 9).

The points alluding to the diagnosing of trouble on the 10-h.p. model apply equally to the 7-h.p. It is more common, however, for roughness to develop in the races on the torque tube on the 7-h.p. model than on the bevel shaft of the 10-h.p.

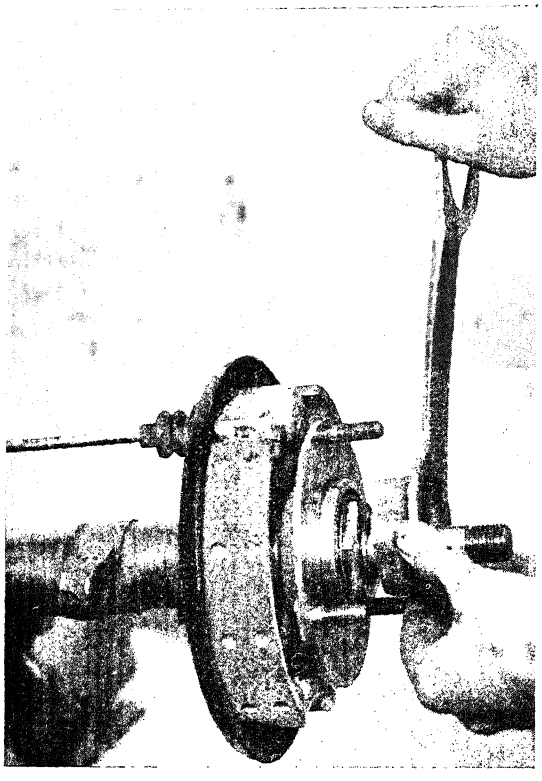


Fig. 10.—SHOWING THE CLAMPING NUT OF THE REAR HALF HUB

Rear Axle Removal

The method of removal for the 7-h.p. model is as follows :

Place trestles under the car at the rear cross-member. Take out the bolts holding the bevel-shaft driving flange to the propeller shaft. Now remove the bolt holding the spherical housing to the silent-bloc bush, or torque anchor as it is termed. The housing will now pull up and away from the bracket. Disconnect the shock absorbers at the bottom links, and the brake cables or rods from the brake cams or levers.

It should be mentioned here that the small 7-h.p. car has Girling-type shoes coupled to the old-type brake cams and cables. The Big 7-h.p. has full Girling brakes right through.

Remove the rear hubs. To do this take off the road wheels and take out the three countersunk screws which hold the drum and two halves of the hubs together. Remove the axle-nut split-pin and nut. Now with a hub drawer pull off the front half of the hub. When the front half hub is removed the locking nut for the ball race and rear half hub is revealed (Fig. 10). Knock up the lock washer and remove the nut with a box spanner. The back half will usually then lever off. If it is tight, replace the front half and tighten it to the back half with the wheel nuts and pull the whole off with the hub drawer. Mark the brake shoes so that their original position can be easily found.

Now remove the cotter pins which lock the spring pins to the axle case. On the Big 7-h.p. the spring pins screw out of the case. On the small 7-h.p. they knock out.

Support the weight of the axle on a box or trestle before removing

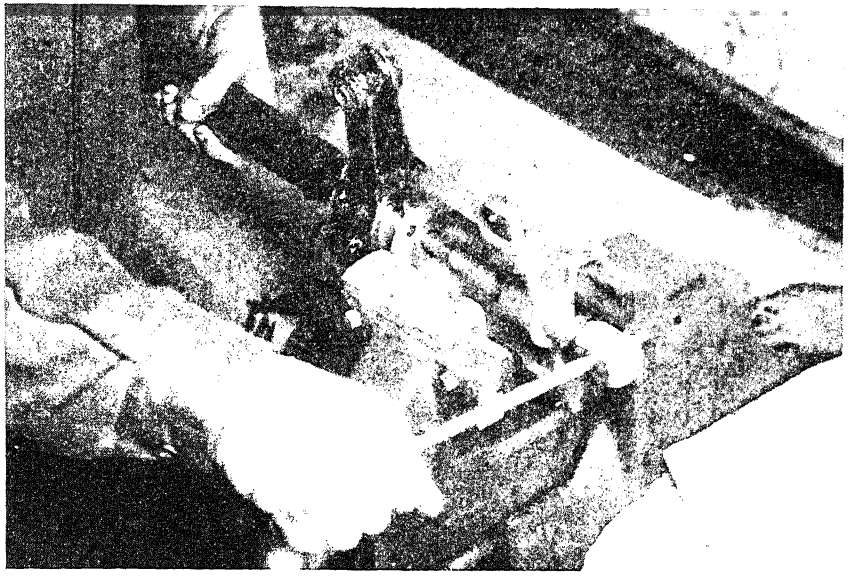


Fig. 11.—WITHDRAWING THE DRIVING FLANGE FROM THE BEVEL SHAFT (7-H.P. MODELS)

them. The axle can now be pulled from under the car, raising the spherical housing to clear the cross-member.

Dismantling

When the axle is removed from the car take out the six bolts which hold the torque tube to the axle casing and pull it out. Remove the nut holding the driving flange to the shaft. With a drawer pull off the flange and take out the key (Fig. 11). Now drive the shaft out of the tube. The pinion-bearing sleeve will tap off the roller bearing. Unscrew the brass gland nut and tap out the front ball race. Knock up the lock washer and unscrew the pinion-bearing nut from the bevel shaft. The thread of this is left hand. Remove the races and distance-piece from the shaft. Turning to the axle case, take out the six screws holding the two halves together. Pull off the nearside or small half and lift out the differential assembly end cross-shafts complete. Open up the differential assembly end cross-shafts and differential wheels. Wash all parts ready for inspection. Test and examine them all in the same manner as for the 10-h.p.

Assembly

The procedure for reassembling the axle is the same as for the 10-h.p. Fit the races on to the bevel shaft. First the roller race, then the distance-piece, lastly the thrust compound. Take care to get the locking nut very

tight before turning over the lock washer. When assembled, insert the shaft in the torque tube, tap the front ball race into position, and clamp it with the brass gland nut. Fit the key, then the driving flange, and again take particular care to get the nut holding the flange very tight before locking with the washer. The floating of the crown-wheel and bevel is carried out in the same way as for the 10-h.p. model. Adjustment for backlash is also the same. End float cannot develop in the cross-shafts of this model in the same manner as on the 10-h.p. because it is governed by the hub races. These should, of course, be examined and replaced if necessary. When fitting and adjusting the spherical housing there should be no slackness, but it should be movable on the sphere.

EXAMINING A CAR FOR ACCIDENTAL DAMAGE AND FRAME REPAIRS

By A. A. BLAKER, M.I.A.E., A.M.I.M.E.

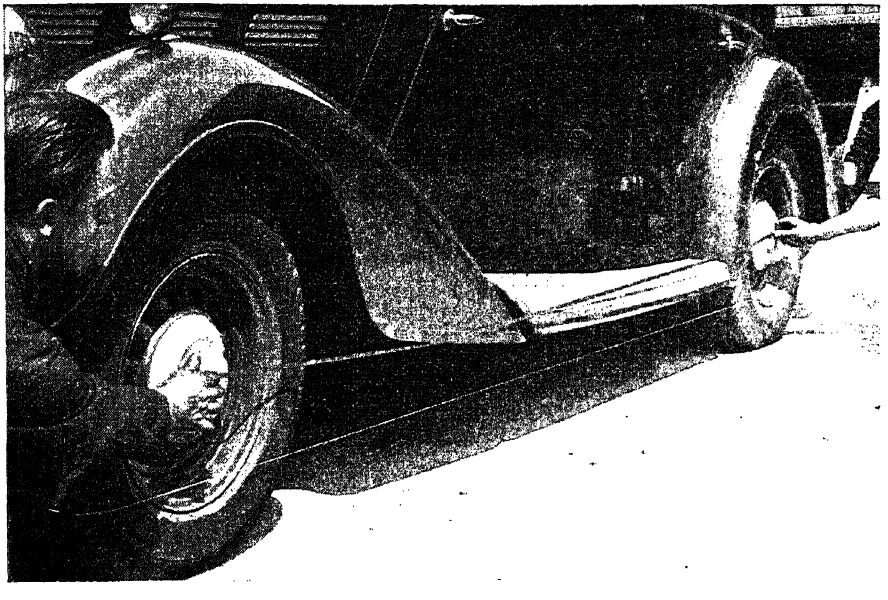


Fig. 1.—CHECKING DISTANCE BETWEEN WHEEL CENTRES

ONE of the most important branches of repair work is that which deals with cars damaged in service, by impact, or which have overturned or otherwise been subjected to abnormal strain.

Most of this work is paid for by various insurance companies, and these companies employ skilled engineers who expect competent repairers to be able to estimate accurately the amount of damage, the extent of dismantling required to enable this to be put right, and the total cost of the work.

Usually the frame of the car suffers to some extent, and it is naturally of very great importance to ensure that this member is correct, and the repairer should be able to check this without dismantling the car or at least with the minimum of dismantling, and in this connection the writer's experience in dealing with many thousands of accidents may prove useful,

more particularly to those repairers who do not specialise in this work, but have occasionally to deal with damaged cars.

Modern Frame Design

The design and method of construction adopted in the manufacture of modern motor-vehicle frames have entirely changed during the past few years ; for whereas most frames were formerly made from steel channel sections riveted together, they now consist of steel stampings or pressings welded together to form a box-section type of construction, braced with pressings of various shape, welded diagonally or at right angles to the side-members ; various fittings are also welded on so that they are no longer detachable.

The appearance of many of these frames will probably strike the repairer as being rather rough, owing to the welding methods used, but cost of production is cut to the lowest limit consistent with economy, and as frames are completely covered by metal shields and mudguards, the finished appearance of the frame is not so important as previously.

When accidental damage occurs, there is now rather more difficulty in determining the amount of resulting distortion, as, owing to the diversity of shapes and sections, and the absence of straight lines, the checking requires greater care.

We have therefore to choose methods of checking which ignore as far as possible the curves and angles of the frame and to work entirely from vital fitting points to locate errors. Several examples illustrating this method are given in this article.

The Likely Points of Damage

When a damaged car is brought in for inspection, a careful examination should be made, not only of the obvious damage, but of the whole of the car. If possible the driver should be questioned, so that the accident may be reconstructed ; this will often give an indication as to where the impact has caused distortion ; for instance, a direct blow on one of the dumb-irons will usually tend to push the whole side-member back, whereas a glancing blow across the front or rear may only bend the dumb-irons themselves, or at any rate, if the damage is in the front, as far as the rear engine support ; again, a blow received directly on one of the front wheels will usually bend the front axle (where one exists), and in addition the rear end of the front spring will force the spring bracket into the frame where it is fitted, and a buckling of the member will be found at this point.

If the point of impact is the centre of the front cross-member, for example when a car is driven or skids into a lamp-standard, there will usually be signs of buckling of the frame in the region of the dash, and it will have sunk at this point. If the blow is received on one of the rear wheels, the axle casing will bend and the wheel arch probably be distorted.

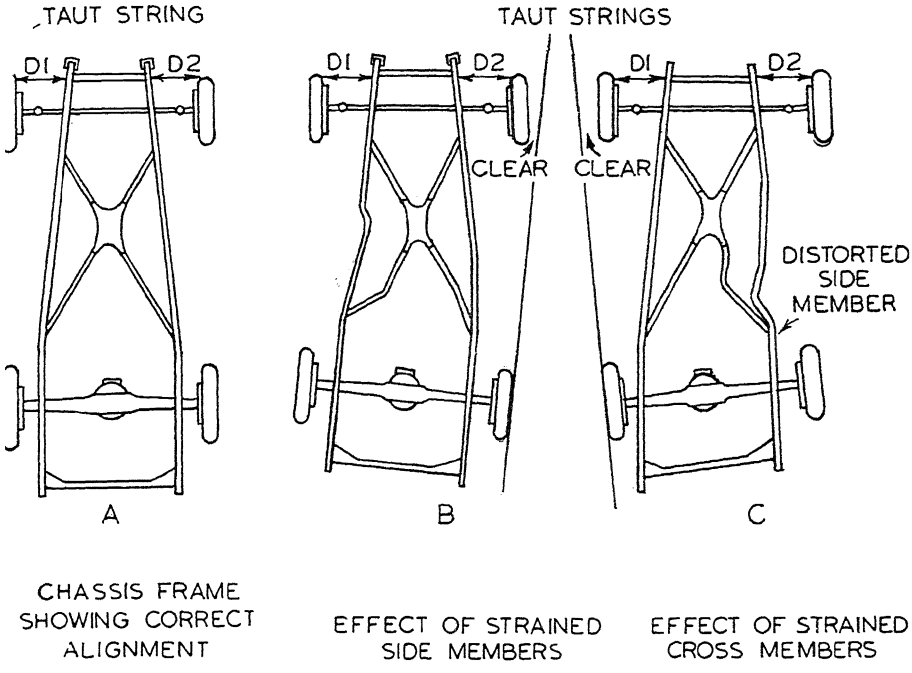


Fig. 2.—CHECKING WHEEL ALIGNMENT

Note.—In no case will D_1 be equal to D_2. When the nearside wheel is set parallel to the string, the toe-in will not allow the offside wheel to be parallel.

Examining Car without Dismantling

If the damage does not appear to be very serious, and there is no obvious reason for any dismantling, the procedure should be as follows :

(1) Jack up the car and test all four wheels for accuracy ; if possible, replace damaged ones.

(2) Wheel the car on to a fairly level piece of floor, stand some distance in front of the car and try to sight the roof of the car, the radiator, and the front wings—it frequently happens that a twisted frame can be seen at once.

(3) If the car looks normal, then examine the fit of the bonnet and the way the doors close, also the windscreen.

Checking Wheel Alignment

(4) This superficial examination having proved satisfactory, the alignment of the wheels and the distance between the wheel centres on each side should be checked, the procedure being as follows :

A thin string is stretched along one side of the car, touching the rear-wheel tyre at two points sufficiently below the centre so as not to catch the spokes of the wheel if these spokes project beyond the tyre. The string



Fig. 3.—TESTING REAR AXLE WITH OPTICAL TRACK TESTER

must also touch the front tyre at the same height from the ground, and the steering wheel must be turned until the string is touching the front wheel at two points. (The front wheel is adjusted in this manner so as to bring the two front and rear wheels in line, that is, in the same plane ; and this method is better than the plan more frequently adopted of adjusting the front wheels equidistant from the frame.)

The string should now touch all four points of the two tyres ; if it does, the wheel centres on this side of the car should be accurately measured and the dimensions written down (don't trust to memory).

If the string touches at three points only, that is, two on the front wheel and one on the rear tyre, it is clear that the rear and front wheels are not in line. This may be due to the fact that some cars have a wider track on one of the axles than on the other, and if this is the case, it will be found that when the other two wheels are checked they will give exactly the same discrepancy as the first two wheels ; in this case the alignment of the two axles will be correct. It is, however, more probable that either the rear axle or the frame is bent, and this will easily be ascertained when the other two wheels are checked.

Testing for Bent Rear Axle or Frame

To decide which is the case, the next procedure is to test the front and back of the wheels on the rear axle with a track tester, and if this test shows the rear wheels to be parallel to each other, then the fault must be either in the frame or in the rear axle, which must have been shifted bodily so that it is no longer at right angles to the centre-line of the car ; this will

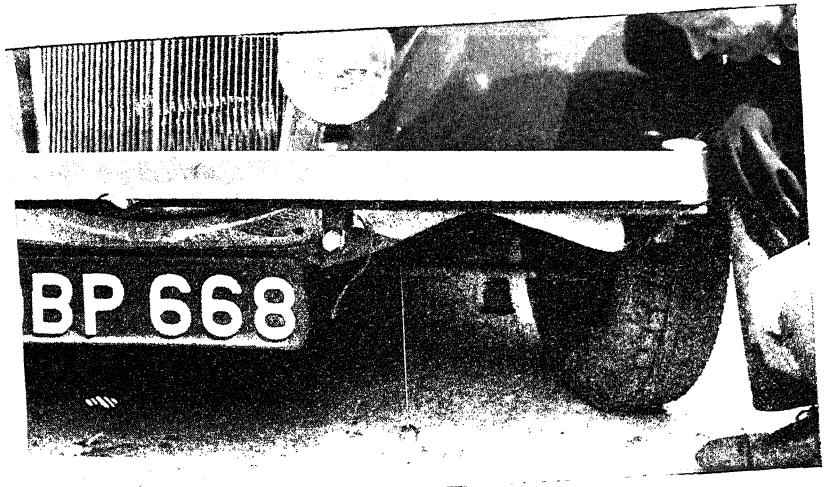


Fig. 4.—CHECKING FRAME ON COMPLETE CAR BY DROPPING PLUMB LINES AND MARKING ESSENTIAL POINTS ON GROUND



Fig. 5.—CHECKING FRAME ON COMPLETE CAR

Points marked on ground have been obtained by dropping plumb lines from car and car has been wheeled away to enable these points to be measured.

be ascertained when the opposite two wheels are lined up, the procedure being exactly the same; if the front axle toe-in is correct, it will be found that when the second side is checked the string will touch the rear point of the front tyre and will be slightly away from the front of this tyre, and the steering wheel will have to be turned to adjust the front wheel in the same plane as the rear; the wheel centres must now be taken on this side and compared with those on the other—if the measurements are within $\frac{1}{4}$ in. the car may be passed as correct.

Should this not be the case, then the body of the car must be removed to allow the errors to be corrected.

The method suggested in the previous example is particularly useful in the case of a car which has been turned over, but which exhibits no definite sign of damage.

Checking for Distortion of the Frame when Wheels or Axles are obviously Damaged

When the frame of a damaged car has to be checked and the wheels or axles are obviously damaged, but there is no definite sign of distortion of the frame, the method is as follows:

Place the car on a fairly clean and level floor. Jack up the car so that it is reasonably horizontal, and put the brake on or wedge the wheel so that the car will not move during the testing. Choose a point on one dumb-iron near the front of the frame—the anchoring pin of the front spring is suitable—and drop a plumb-line to the ground. Where the point of the plumb-bob touches, chalk the ground and draw a cross with a pencil or scriber so that the centre of the cross represents the plumb-line; do the same on the other side of the frame and mark a similar cross. Now go to the rear of the frame, and, choosing similar points, drop plumb-lines and mark two other crosses on the floor.

You now have on the ground four crosses which accurately represent the extreme corners of the frame, and if the car is moved away the dimensions of the diagonals and lengths of the side-members can be determined exactly. If opposite dimensions are within $\frac{1}{4}$ in. the frame can be passed unless the car has received impact on one side. If this is the case, further points must be taken on each side of the frame and plumb-lines dropped to the ground (suitable points are at rear of front springs and front of rear springs and one each side in the centre of the frames). You will now have five crosses on the ground on each side of the frame, and if the car is moved away, an exact copy of the essential points of the frame are pictured on the ground. The points at each end of the frame can be joined by lines and these lines bisected, and a line representing the centre of the frame can be marked by stretching a chalked string between them, carefully lifting the centre of the string and releasing it so that a white line is marked on the floor. From this centre-line all the points marked

can be checked and it is quite a simple matter to decide whether the frame is bent.

The two examples given may appear to entail a considerable amount of labour in checking, but actually this is not the case, as the written explanation of the methods employed has to be somewhat lengthy to be clearly understood.

EXAMINING CAR WHEN FRAME IS OBVIOUSLY DAMAGED

Deciding on Amount of Dismantling Required

Where the accident is of such a character that the frame is obviously damaged, the point to decide is the amount of dismantling required; some typical cases are dealt with.

First Example—Impact on Offside Front Wheel and Wing

This example is where impact has taken place on the offside front of a car, resulting in a damaged wing, bent front axle, and damage to the frame at the point where the rear end of the front spring is anchored. This frame damage may be confined to the one point alone, but more probably there will be further distortion; the frame member will be bent at least as far towards the rear of the car as the first junction of the cruciform.

Raise the car so that the underside of the frame can be inspected, and feel along the frame at all junctions between side-members and cross-members; do not take notice of slight unevenness of the metal at these points, as the process of manufacture sometimes causes this; but if there is any definite evidence of buckling, the frame is bent at this point; if no damage is visible, try the angles formed by the junctions of the side-members with the cross-members by means of an angle gauge wherever this can be applied.

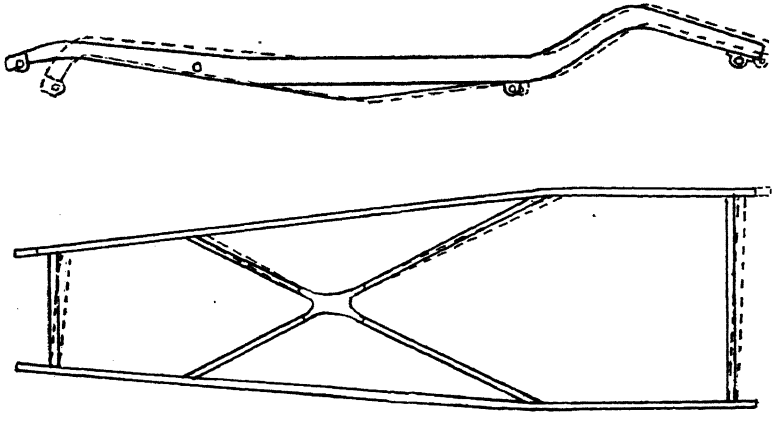


Fig. 6.—EFFECT OF OFFSIDE FRONT IMPACT

The dotted lines indicate the points of distortion that might be discovered.

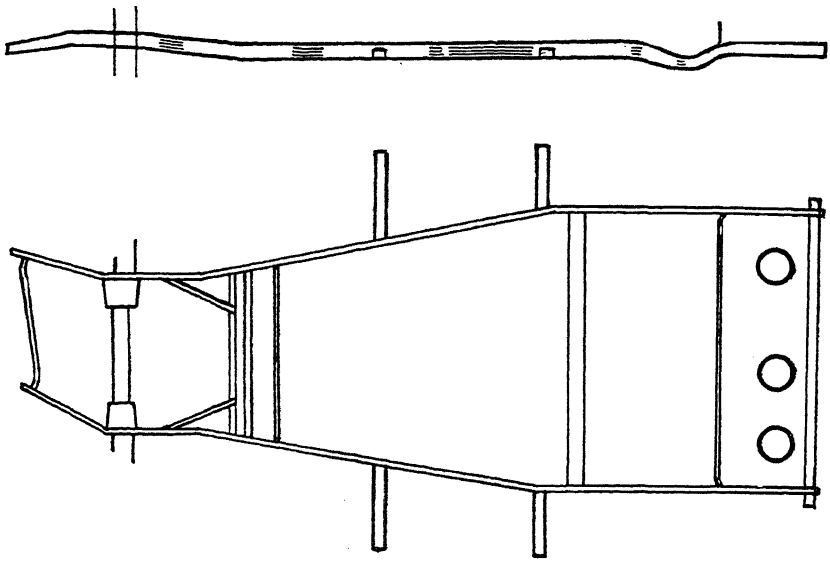


Fig. 7.—EFFECT OF FRONT IMPACT CAUSING ONLY DUMB-IRON DAMAGE

If the result of examination shows that there is no damage behind the dash, it will not be necessary to remove the body to execute the repairs.

It is, in every case of this description, advisable to examine the engine bearers to make sure none of these has been bent or fractured.

Second Example—Impact on Offside Front Dumb-iron

The previous example was given on the assumption that impact occurred on the front wing and wheel; we will now consider what is likely to happen if a similar blow, occurring at about the same part of the car, but just missing the wheel, is received directly on the end of the dumb-irons. In this case there may be no damage to the front axle or the side of the frame, but the whole side-member may be pushed back relative to the rest of the frame, and this will necessitate removal of the body and engine to repair. The simplest test for this, if there is no visible distortion of the frame, is to drop a plumb-line and mark the position of the four extreme corners of the frame on the ground, as previously explained. Then wheel the car away and measure the two diagonals; if these vary by more than $\frac{1}{4}$ in., the side-member has been pushed back; of course, if the dumb-iron itself is bent or broken, the extreme front of the car cannot be used for dropping the plumb-lines, but points may be dropped from the rear end of the front springs.

To Test for Twisted Frame

To test for a twisted frame on a car which is not dismantled may appear somewhat difficult, but if a jack is placed under the centre of the front

axle and the height of the rear ends of the frame is measured from the ground, and the end which is nearer the ground jacked up to equal the other, then measurements taken from the two front ends to the ground should equal each other if there is no twist in the frame (an error of $\frac{1}{8}$ in. is allowable). This test must be made on a reasonably flat floor.

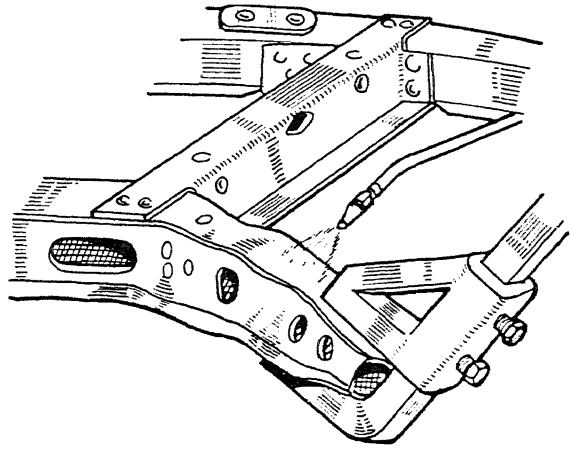


Fig. 8.—RESETTING OF FRONT DUMB-IRON

Where the body, wings, and radiator have been removed, the frame can be tested by means of a spirit level applied to parallel pieces of metal placed across the frame as far apart as possible and at right angles to the centre-line of the frame. If the same test is required on a frame which is completely stripped out, the parallel bars can be placed in the same manner and they can be sighted for any twist.

Repairing Crushed-in Frame

When the damage to the frame has been ascertained and the amount of repair decided upon, the question as to whether it is within the capacity of the repairer will depend on the nature of the distortion.

If the frame is crushed in it will be shortened, and this must be corrected as the section is brought back to its original shape. To do this fix some form of expanding jack between cross-members on either side of the damaged part, as shown in Fig. 12, apply pressure, and if the distortion is not too great, the frame will probably be

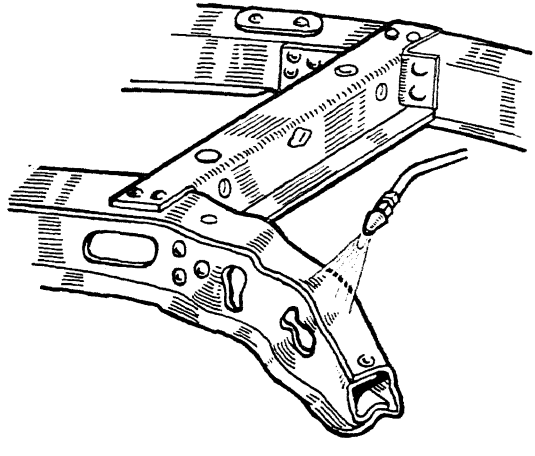


Fig. 9.—DUMB-IRON DAMAGE, SHOWING POINTS WHICH HEAT SHOULD BE APPLIED

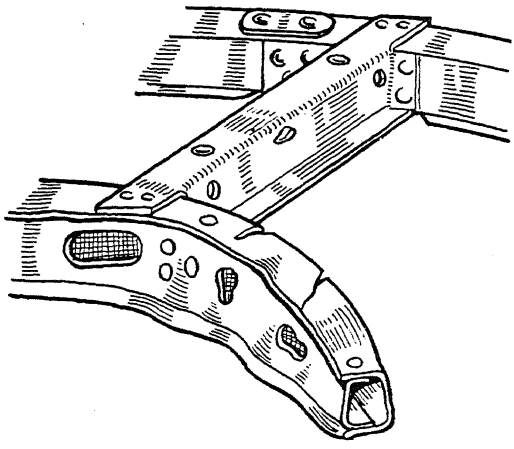


Fig. 10.—DUMB-IRON DAMAGE, SHOWING CRACKS CAUSED BY EXCESS TENSION

stretched back into its correct shape without the use of any heat. In any case, use as little heat as possible, as the application of heat on the thin metal used in the construction of the frame will tend to still further shorten the damaged part and render the frame useless.

If the method suggested is not successful, proceed to cut away a side of the frame section at the damaged part so as to leave the other three sides forming a channel; this will then be more easily dealt with, and a new piece of plate can then be welded in; when this is trimmed off the repair should not be visible. The frame must again be checked after welding, as some distortion will take place.

Welding-in New Sections of Damaged Frame

However badly a frame is damaged, it is now possible to repair by welding-in new sections. These may not be obtainable from the manufacturers and therefore have to be specially made by hand; the point which the repairer has to decide is whether the repair is more economical than the purchase of a new frame.

Where the metal body of the car is riveted to the frame, it is usually possible to repair the frame without removing the body, even when the damage is very considerable or at the rear end of the frame, and this procedure is advisable, as the refitting of these bodies after repair is

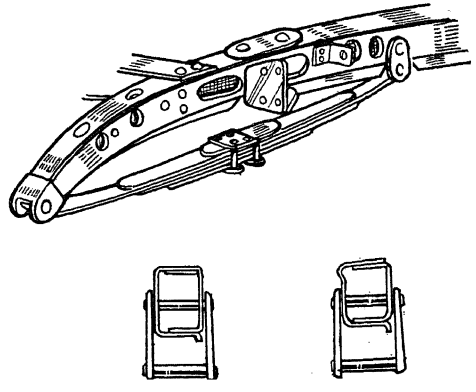


Fig. 11.—DISTORTION OF SIDE-MEMBER SECTION AND RESULTING DISPLACEMENT OF SPRING

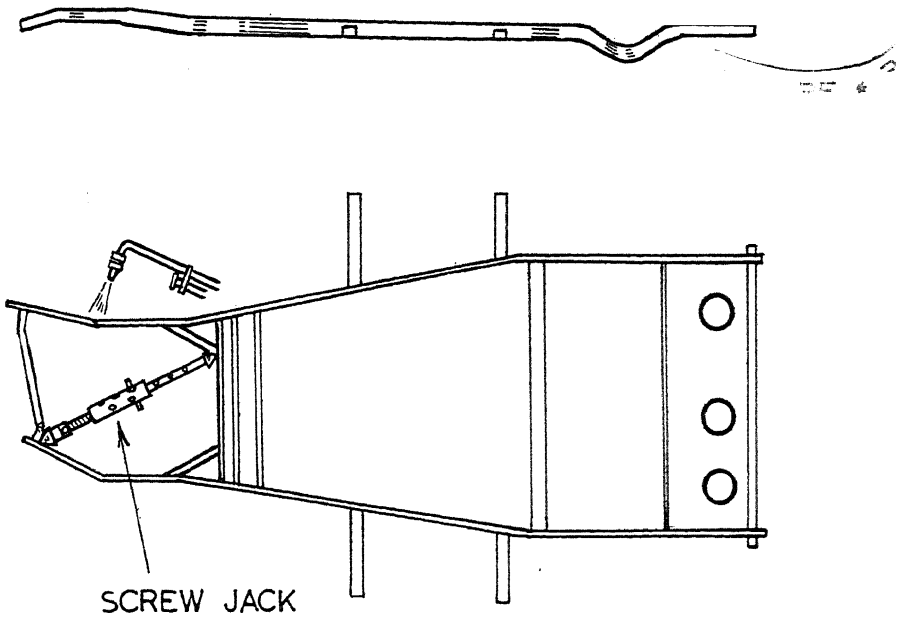


Fig. 12.—METHOD OF REPAIRING CRUSHED-IN FRAME

Showing expanding jack fixed between cross-members on either side of the damaged part. If the distortion is not too great, the frame will probably be stretched back into its correct shape without the use of any heat. In any case, use as little heat as possible.

expensive, and if the straightening work is beyond the scope of the repairer the employment of a specialist will probably prove economical.

When a chassis has been dismantled for repair to an all-welded frame, it is always necessary to examine carefully the original welding, which may have given way as the result of the accident, particularly at the junction of cross-members and side-members, and it may be found that welds which are some distance from a point of impact have been affected.

Methods of Reinforcing Broken Frames

The usual methods employed in reinforcing broken frames are enumerated as follows:

(1) Inside sleeves can be inserted to cover the fractured part and welded in position. This is a most suitable reinforcement for commercial-vehicle frames, doubling, as it does, the original thickness of the frame.

(2) "Boxing in" can be satisfactorily used in many private-car frames. This is carried out on a channel-section member by edge welding a fourth side where necessary so as to form a complete box section. It

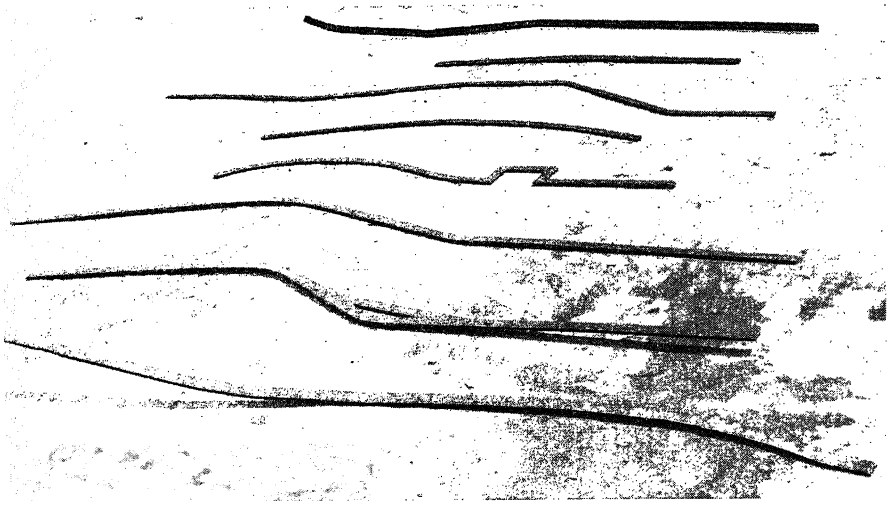


Fig. 13.—STEEL TEMPLATES BENT TO CHECK CONTOUR OF FRAME MEMBERS

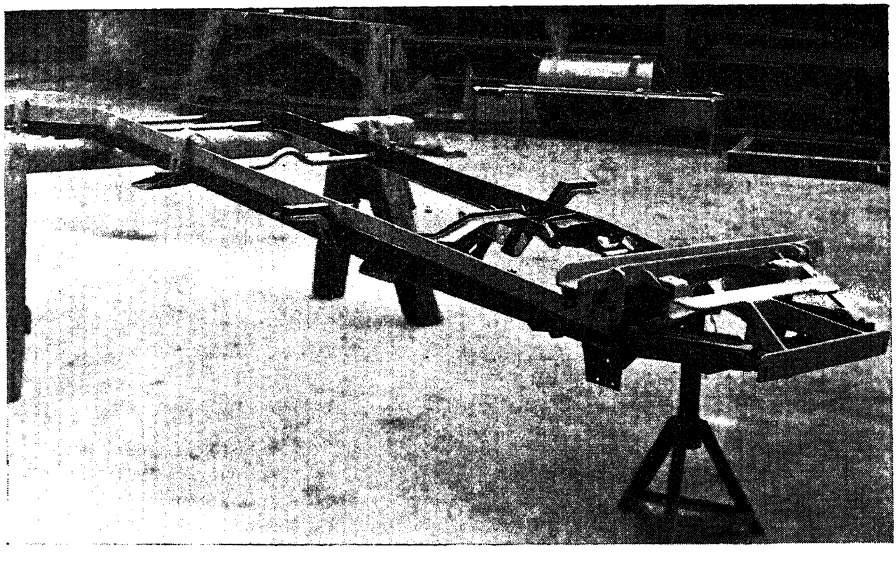


Fig. 14.—MODERN BOX-SECTION CHASSIS FRAME WITH JIG IN POSITION

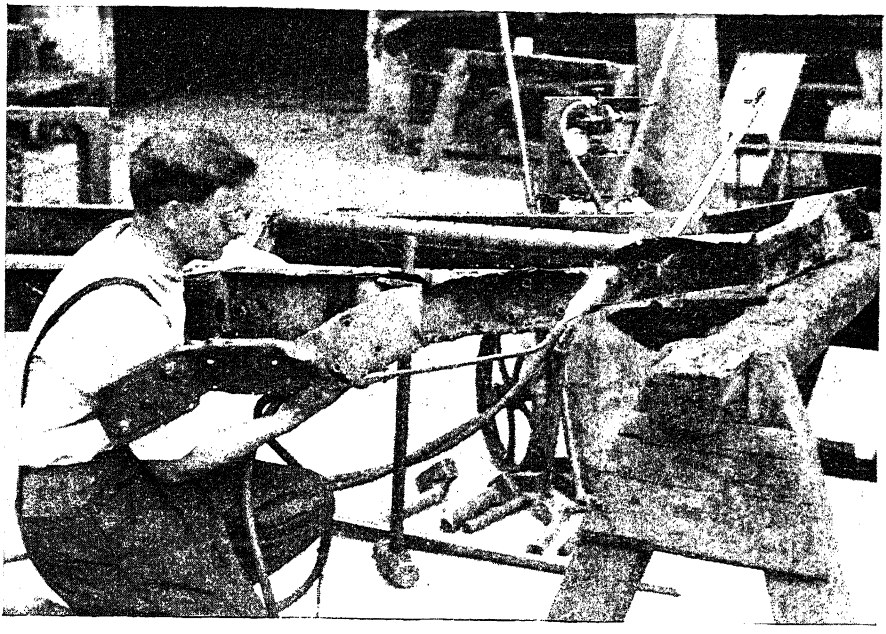


Fig. 15.—CUTTING SIDE OUT OF SECTION OF BADLY DAMAGED BOX FRAME TO SIMPLIFY STRAIGHTENING

The completed job is shown in the next Figure.

may be necessary to drill holes in this reinforcement so that bolts in the original members may be accessible.

(3) Where box-section frames are fractured it is often possible to remove one side of the section, reinforce with an inside plate, and replace the side, thus making an invisible repair.

(4) Where brackets and other fittings make it impossible to use other methods, the bottom flange of a side-member may be reinforced by welding a lip to the flange, thus increasing its width.

Where any of the above methods are used, and in fact where any welding is carried out on a light frame, it is important to remember that distortion will take place, and this must be corrected.

Method of Telling if Frame is bent without Measurement

In many cases of inspected damage to the chassis frames of complete vehicles there are external indications which may be of great assistance. A few of these are mentioned below:

(1) The engine bearer arms should be carefully examined. In order to provide the necessary flexible mountings the engine bearer plates are now frequently of light section and will bend when distortion of the front

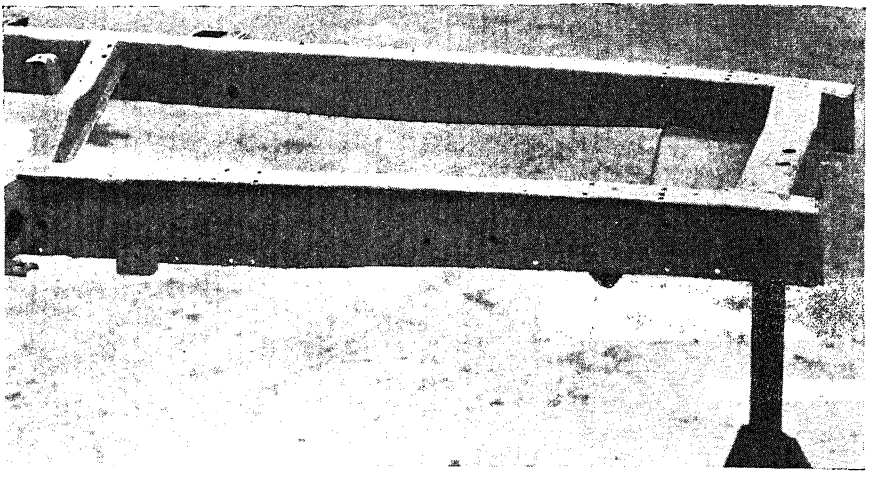


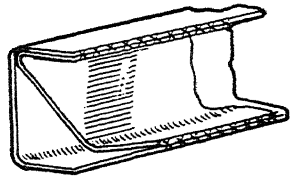
Fig. 16.—BOX SECTION FRAME FROM WHICH SECTION WAS CUT DURING REPAIR
The original damaged frame is illustrated in the previous Figure.

end of the frame takes place. (It should be noted, however, that it may happen that the sudden stopping of the vehicle, due to an accident, will cause the engine to jump forward, but in this case the engine bearers are usually bent equally both sides.)

(2) The position of the steering column where it passes through the bulkhead of the body is frequently a guide to possible frame distortion. If the column is forced over to one side of the hole in the bulkhead the front end of the frame may be bent, but here again it is necessary to be certain that (*a*) the column itself is not bent, or (*b*) the bulkhead is not distorted.

(3) If the starting handle does not register with the dogs on the engine it is again frequently the case that the frame may be bent, but in cases where the engine is mounted on the front cross-member with a heavy bracket, it is possible for the front end of the frame to be considerably out of line although the starting handle engages correctly. This is due, of course, to the fact that the engine is brought round with the chassis frame.

(4) The fit of the bonnet is a most important indication of frame alignment so long as the radiator and bonnet themselves have not been damaged. A gap at the lower end of the rear of the bonnet is often a reliable indication that the frame has sunk immediately under the bulkhead. Also, if one corner of the bonnet at the rear is overlapping the body while there is a gap between the opposite corner at the front and the radiator, this may mean that the front end of the frame is out of square.



CHANNEL REINFORCEMENT

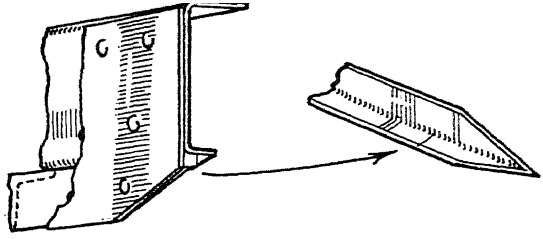


PLATE & ANGLE REINFORCEMENT

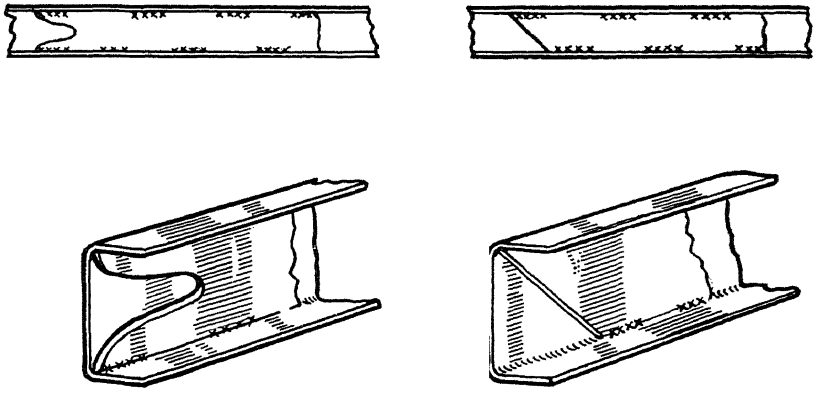


PLATE REINFORCEMENT
SHOWING STAGGERING OF THE STITCH WELDING USED

Fig. 17.—METHODS OF REINFORCING BROKEN FRAMES

EXAMINATION OF INDEPENDENT FRONT-SUSPENSION UNITS FOR SUSPECTED ACCIDENTAL DAMAGE

The Buick Type of Suspension

This group includes many well-known makes, including Packard, Daimler, and Oldsmobile.

This method of suspension employs coil springs, and from the point of view of suspected accidental damage this system has two distinctive features :

(1) That the offside and nearside assemblies are mounted quite independently (usually on a very heavy chassis frame front cross-member) and are connected only by the necessary steering connections. As the latter are normally lighter in section than any of the suspension parts, it follows, therefore, that it is sometimes possible for one of the suspension units to receive a very severe blow indeed without affecting the other side.

(2) The upper control arm of the suspension mechanism is usually made integrally with a powerful shock absorber, which thus controls the whole vertical movement of the wheels. It is therefore essential that these shock absorbers should be in proper working condition, and a bent spindle which may result in partial seizing of the shock absorber is sufficient to hold down that side of the car ; this, of course, can be checked by releasing the shock absorber on that particular side.

A frequent result of damage to this type of suspension is that a blow on the wheel is transmitted through the lower control arms to the front cross-member, which often becomes buckled or torn at the point where the control arms are mounted.

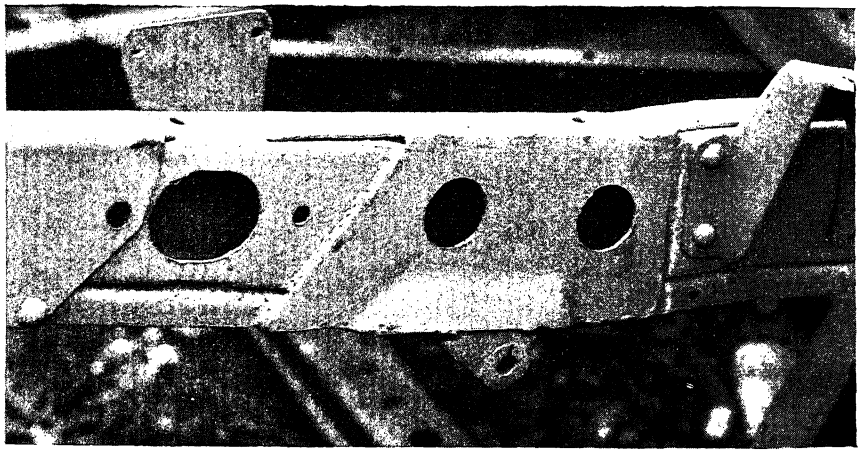


Fig 18.—SPECIAL METHOD OF REINFORCING BROKEN SIDE-MEMBER ABOVE SPRING BRACKET

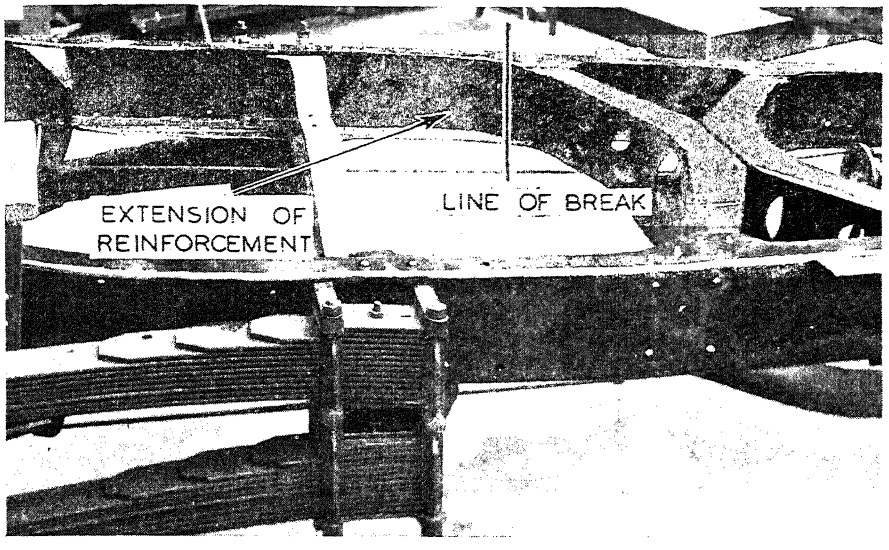


Fig. 19.—METHOD OF REINFORCING BROKEN EXISTING FRAME BY EXTENDING "BOXING-IN" AND BY WIDENING LOWER FLANGE OF MEMBER

Tracking and checking the splay of the wheels provides a good method of determining whether the suspension has suffered damage, but care must be taken to see that the car is loaded with the correct weight on the front end. If the wings and radiator are removed, for example, it is obvious that the splay of the wheels cannot be accurately determined.

In a case where one particular part of the mechanism is known to be bent, it is essential that all other parts on that side should be dismantled and carefully checked either with jigs or with manufacturer's drawings. Bent parts of the suspension mechanism may generally be straightened, but if heat is used the parts should be re-heat-treated after resetting. On no account should broken parts be welded unless they are units which have been originally constructed by welding, and even then discretion should be used.

The Vauxhall Type of Suspension

Similar types to the Vauxhall suspension are the Opel and Chevrolet.

Many of the foregoing remarks apply to this type of suspension, but there are one or two important distinctions when checking for suspected damage.

(1) The offside and nearside assemblies are in this case mounted on a rigid beam, often of tubular section (on a steel pressing in the case of the Chevrolet), which is attached to the chassis frame and forms the front cross-member of the frame. The ends of this beam are similar to the eye

ends of an ordinary front axle, and the assemblies are mounted with a pivot pin in the usual manner.

Whether the car is hit on the front of the frame or on a wheel, this beam then, is very likely to suffer damage. It should be dismantled and checked with jigs or drawings if malalignment is suspected. Provided the work is carefully carried out, these beams may often be reset.

(2) In this type of suspension it is often extremely difficult to determine by a superficial examination whether the actual suspension parts (some of which are enclosed) are bent, and if wheel alignment appears to be incorrect it is better to dismantle and check each part independently, and as these parts are often, of necessity, of irregular design, the proper jigs should be employed.

The Citroën Type of Suspension

This employs the torsion-bar method and (in the case of the Citroën) in conjunction with the front-wheel drive.

When checking for suspected damage on this type of car it is important to note that some parts of the suspension are mounted as far back as the steel pressing at the rear of the engine, and it frequently happens that these mountings are distorted in an accident, and this may be readily seen.

Distortion of the cradle-type front cross-member of these cars will also sometimes give an indication of suspension damage.

The Hillman and Humber Type of Suspension

The Studebaker and Standard are also similar to the Hillman and Humber suspension in many respects.

This method employs a transverse spring, in conjunction with control arms or a second transverse spring. Care should be taken, when checking for damage on this type of car, to see whether the spring leaves are bent or the eyes unrolled. It is also possible that the springs may move bodily as the result of a severe impact, and this cannot always be seen without dismantling. Here, again, the mounting of the suspension units on the front cross-member of the frame is most important, and signs of damage on the member should give an indication as to suspension damage.

In general, the following points may be of assistance when examining a case of suspected damage to front-suspension units.

(1) The track and camber of the wheels should always first be checked.

(2) The points where the suspension parts are attached to the frame should be carefully examined for signs of buckling or fracture.

(3) Where alignment of the suspension is determined by brackets or shock absorbers mounted on flat faces of the frame or front cross-member, these faces should be checked and compared with straight-edges.

(4) In some cases measurements can be taken from a fixed point on the side-member to the suspension units, but it must be remembered that

tolerances are very small indeed on independent suspension units, and generally only fairly large errors can be found in this way.

(5) It should be mentioned that tyres play a very large part in the correct action of the suspension, and worn tyres or incorrect tyre pressures have been found to account for what appeared at first sight to be accidental damage. It is also very necessary to see that no undue wear is present in any moving parts, and that steering connections in particular are in proper condition.

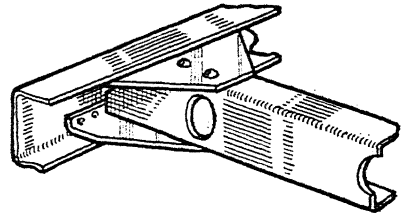


Fig. 20.—REINFORCEMENT OF CROSS-MEMBER BY MEANS OF TWO GUSSETS

(6) It is frequently of great assistance, when both the chassis frame and suspension units have been repaired, to assemble these parts together and check wheelbase length and wheel alignment before the final assembly of the car is proceeded with. This applies particularly to those cars in which the suspension, assembly forms the front cross-member of the chassis frame, as slight distortion to both the frame and suspension units can sometimes be caused during assembly.

(7) The point should be noted that, with a very large number of independent suspension units, provision is made, either by an eccentric bush or other means, for final accurate adjustment of wheel alignment, and where very small errors are detected these can often be overcome in this way. Provision is also sometimes made for adjusting the height of the suspension, and this, as with all other alignment adjustments, should be carried out on the completely assembled car.

(8) It will be noted that with the majority of types of independent springing the question of wheel alignment is very closely linked with the chassis frame front cross-member, and although damage to the one does not necessarily imply that the other has suffered, it is important to regard the two assemblies, that is, the front cross-member and the suspension mechanism, as one whole unit which, when complete, determines the correct front-wheel alignment of the car.

(9) In almost all methods which are used in independent suspension it is safe to say that the shock absorber plays a most important part in the control of the very flexible springing obtained, and, after an impact, it is necessary to see that these essential units are functioning correctly, otherwise trouble may be experienced even though no suspension parts are bent and wheel alignment may be correct.

WORKING TOLERANCES AND ALLOWABLE LIMITS OF ERROR ON CHASSIS FRAMES

It frequently happens that small errors which may be found in a chassis frame after an accident give rise to the very important question

of tolerances, and sometimes it may be necessary to obtain the expert opinion of a specialist as to whether the errors should be rectified.

Centre Line at Rear of Engine

To take one or two familiar examples. An error of $\frac{3}{16}$ in. (not in itself a large discrepancy) in the centre line of the chassis frame at the rear of the engine will mean that the propeller shaft will be double the amount, i.e. $\frac{3}{8}$ in., nearer to one side-member than to the other, which may be sufficient to cause the propeller shaft to hit an obstruction on the frame when the car is in motion.

Length of Wheelbase

On the other hand, an error of $\frac{1}{4}$ in. in the length of the wheelbase may be due to an accumulation of small original errors in the chassis frame and axle assembly, and, provided that wheel alignment is within limits, this $\frac{1}{4}$ in. error in the wheelbase may often be ignored.

Diagonal Measurements of Frame

For the same reason, a difference of $\frac{3}{16}$ in. between the diagonal measurements of the frame (inasmuch as the frame alignment is only very slightly affected by this discrepancy), can be allowed.

Independently Sprung Chassis

There are occasions, however, when the rectification of a small error is essential. For example, the flat faces on the front cross-member of an independently sprung chassis which carry the upper control arms of the suspension must be correct to within at least $\frac{1}{16}$ in., as a small error here will be greatly magnified at the wheels.

Rear Spring Bracket

Again, supposing a spring bracket at the front end of the rear spring is twisted under, owing to a blow on a rear wheel, it may necessitate extensive dismantling and removal of the body to reset the bracket if this is inaccessible, but the work should certainly be carried out, otherwise trouble may be experienced with the rear spring.

As in all checking after accidental damage, this question of allowable limits is of the greatest importance, and it frequently needs considerable experience to decide whether a very small error should be corrected or not.

It should be remembered that a car owner may exercise his right to have the car examined by the manufacturers after repairs have been carried out, and although an error which has been passed by the repairer may in no way affect the performance or assembly of the vehicle, it is obvious that the manufacturers cannot be expected to pass something which is wrong. Any error which is found should have the closest consideration before deciding whether to repair or not. As a general rule, it may be said that any discrepancy which is sufficient to cause malalignment of the wheels must be corrected, and this point cannot be too strongly stressed.

Always Check Wheel Centres after Repairing a Damaged Car

When a damaged car is reassembled after repair, it is of the utmost importance that the wheel centres are correct, and these should always be tested before finally delivering the car.

If they are not correct, the trouble may not lie with the frame. More frequently it is due to the axles not being correctly mounted on the car. There is usually a certain amount of clearance in the axle bed where the locating spigot bolt (which bolts the spring together) is fitted, and this allows the axle to be mounted slightly out of square. It is therefore advisable to look for this trouble before further checking.

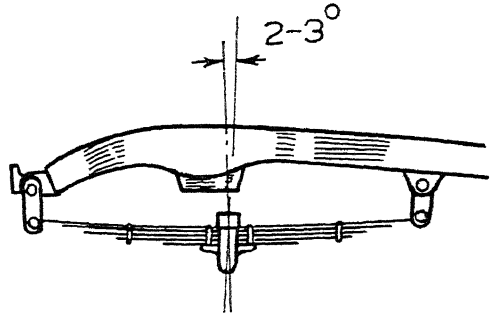


Fig. 21.—APPROXIMATE ANGLE AT WHICH AXLE PIVOT PIN SHOULD LIE WHEN VIEWED FROM SIDE OF CAR

When Reassembling, mount Springs on Frame before Axle is Fitted

Some repairers make a practice of bolting the springs to the axles before mounting to the chassis ; this is wrong, as the spring clips do not locate the springs correctly. They should, therefore, be mounted on the frame before the axle is fitted.

It sometimes happens that when a car is completed, the road performance is not satisfactory owing to some form of steering trouble ; the car may drift towards one side of the road or wheel wobble may develop.

Drifting of Car due to Front-axle Twist

In over 90 per cent. of these cases the trouble is finally traced to the front axle, drifting of the car being usually due to one end of the axle being twisted relative to the other, and front-wheel wobble is the result of wrong assembling of the axle bed on springs.

In Fig. 21 is shown the approximate angle at which the axle pivot pin should lie when viewed from the side of the car. This varies slightly, owing to various reasons, but an extremely small difference in this angle will start or cure wheel wobble, and it is a case of trial and error to determine the exact packing necessary between the springs and the axle bed.

Nickel-steel Frames require Special Treatment

The majority of popular-car chassis frames are in mild steel. Some manufacturers, however, use a nickel-steel, and care should be taken to examine the damaged portion of the various members for flaws and incipient cracks. When any doubt exists it is advisable to send the damaged frame to a firm who specialise in this work.

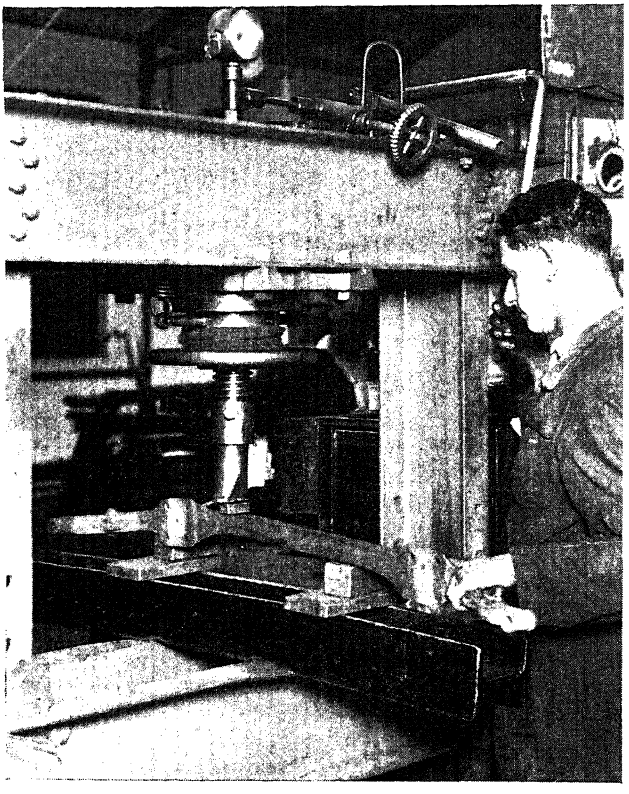


Fig. 22.—STRAIGHTENING BENT FRONT AXLE BEAM UNDER HYDRAULIC PRESS

FRONT AXLE AND FITTINGS

In a very large number of cases of accidental damage to cars, the front axle is subjected to abnormal stress, and even when no impact occurs the sudden application of the powerful front-wheel brakes which are fitted to modern cars will tend to twist the ends of the axle, particularly if they are of I-section. It is therefore imperative that examination of the axle is made a special feature of car checking. Unfortunately it is not possible to test this component accurately while it is attached to the car, but if the spring clips are disconnected and the front of the car jacked up, the axle may be wheeled from under the car if the steering and brake fittings are first disconnected. If a cursory examination shows that the axle beam is bent, the axle must be completely stripped and the beam straightened or replaced by a new one.

The swivel axles, king-pins, and brake drums must all be tested in a lathe, as it is quite usual for some of these parts to be damaged if the beam is bent. It is not advisable to have the stub axles or steering arms straightened; they should be replaced with new ones if damaged.

Checking for Bent Axle Beam

When there is no obvious damage to the beam, the complete axle should be packed up or held in a vice in such a manner that one of the spring platforms is horizontal; this should be set by means of a spirit-

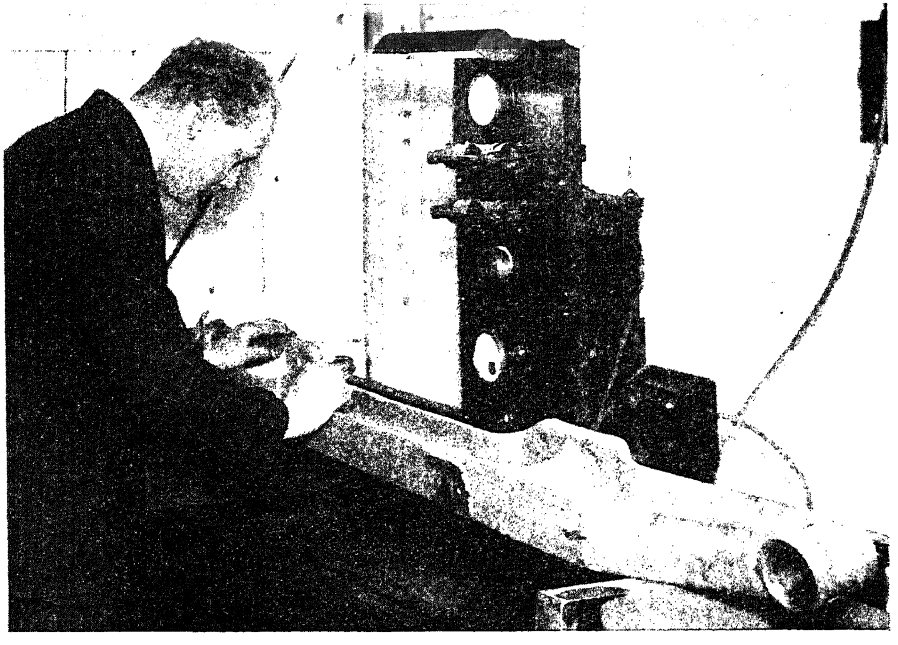


Fig. 23.—EXAMINING FRONT AXLE IN MAGNETIC TESTING MACHINE FOR POSSIBLE FLAWS

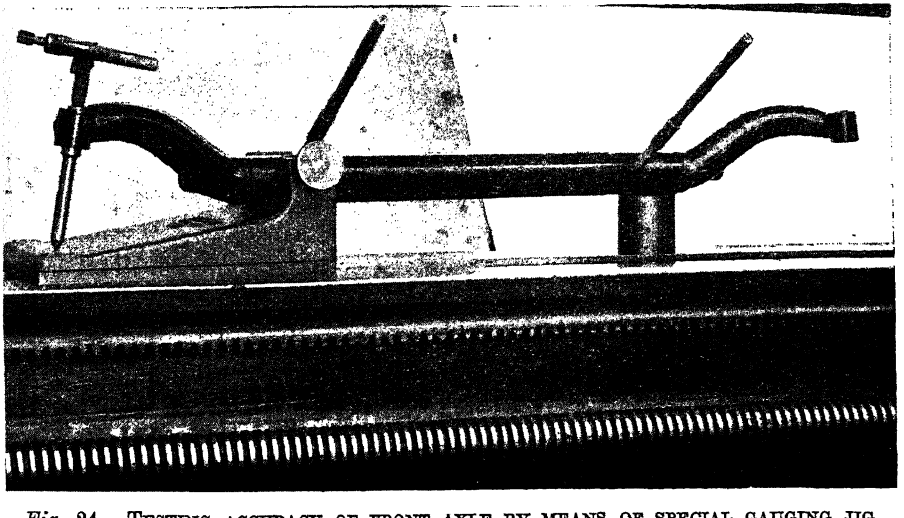


Fig. 24.—TESTING ACCURACY OF FRONT AXLE BY MEANS OF SPECIAL GAUGING JIG

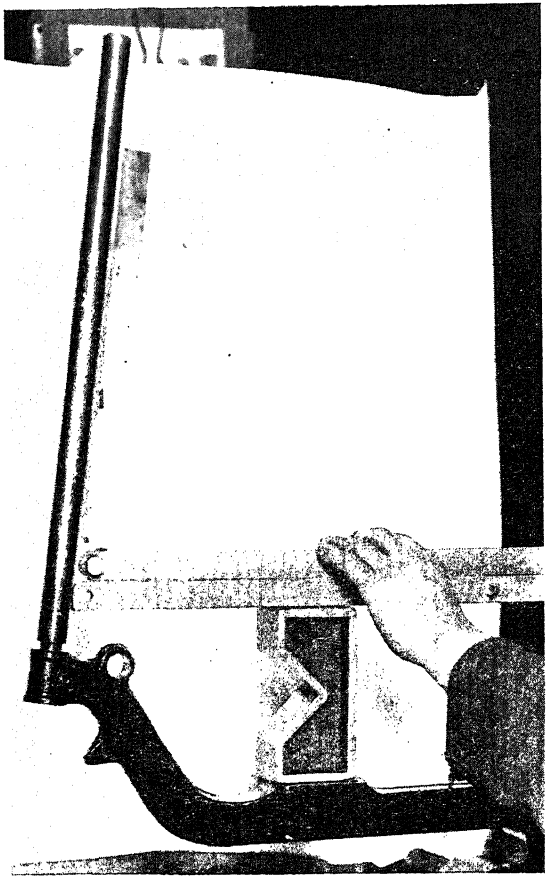


Fig. 25.—CHECKING ANGLE OF KING-PIN BEARING ON FRONT AXLE

level, which should then be placed on the other platform to check whether that also is horizontal; if it is not, the axle beam is bent and the axle must be stripped.

If the two platforms are correct, the spirit-level may be placed on top of one of the king-pins, first in line with the centre-line of the beam and secondly at right angles to it, and the amount the bead is out of centre in the spirit-level should be noted and compared with similar tests made on the other king-pin; if each king-pin gives similar readings, there is no twist in the axle, and the only other check necessary will be to stretch a thin string from the centres of the two king-pins and try with a square off each platform to see whether the line of the string runs through the centres of the platforms. If this is correct, the axle may be passed, and there should be no necessity to dismantle it.

Straightening Front Axle

When dealing with a bent front-axle beam, it is of the utmost importance to decide whether it will be possible to straighten it without the application of heat, for if any heating is necessary the axle will usually require to be re-heat-treated after straightening to restore inherent properties. As a general rule, it is safe to straighten cold if the bending has been of such a nature that the metal has not been stretched to any extent. It is good practice to examine the bent portions of an axle by means of a magnetic tester, which will immediately show up any incipient cracks or flaws which may exist.

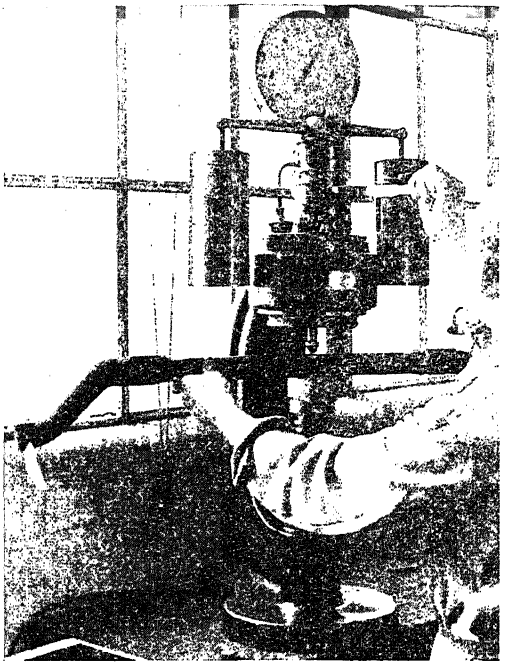


Fig. 26.—TAKING BRINELL TEST ON FRONT AXLE
This test is taken before and after repair when reheat treatment is necessary.

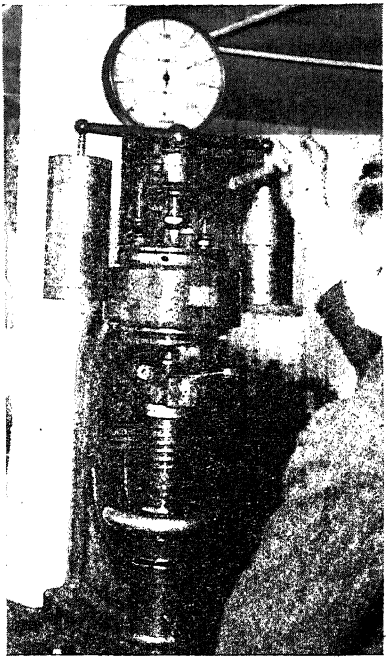


Fig. 27.—BRINELL TEST OF STEERING CONNECTING ARM

Testing Axle Beam for Accuracy

To test a stripped axle beam for accuracy, the beam should be held in a suitable vice and a straight-edge placed on the two spring platforms parallel to the centre-line of the beam ; this will show whether they are both in one plane. If this test is satisfactory, two straight-edges, or parallel strips, should then be rested on the platforms at right angles to the centre-line of the beam, and by standing some distance from one end of the axle, it will be possible to sight both of the top edges of the strips and to see at once whether there is any twist between the spring platforms.

A parallel rod about 18 in. long should be placed in each of the king-pin bearings at the ends of the beam and sighted in a similar manner to see if there is any twist relative to each other, and if the axle is a reversible one, they should also be sighted against a square placed across a spring platform at right angles to the centre-line of the beam.

An angle gauge should then be set to the correct angle given by the manufacturers for the particular axle under examination, and this angle should be tested from parallel packing-strips placed on the spring platforms. This angle should be correct within $\frac{1}{16}$ in. (which represents about

$\frac{1}{4}°$) as it governs the angle which the plane of the front wheel makes with the road.

The only other test necessary is to stretch a thin string between the centres of the king-pin bearing holes and see that the centres of the spring platforms are in the same line.

A point which frequently arises when the axle or steering connections are badly bent in an accident, is how to straighten these parts sufficiently to enable the car to be towed to a garage, and this may be overcome by heating the damaged parts and roughly straightening them on the car ; if this is done, the steering parts must not be used again but must be replaced by new ones.

After Heat Treatment

When the damaged parts are to be straightened and re-heat-treated, a Brinell test should be taken before any work is started on them and again when they are finished, so as to check the heat-treatment. The parts should also be carefully checked for accuracy, as heat-treatment affects this in many cases.

REAR AXLE

The rear axle is another component which frequently suffers damage when a car is involved in an accident. This damage is often overlooked unless it is quite obvious ; in fact, in many cases, even when a car has been badly smashed up and had to be completely stripped and the frame straightened or replaced, there has been no suspicion on the part of the repairer that there could be anything wrong with the rear axle, and the car has been finished ready for the road before anything wrong was suspected. Even then, the repairer or owner (knowing the frame to have been seriously damaged) concludes that this has been badly repaired. The writer is frequently called upon to inspect cases of this nature, and often finds that the car has again been stripped to locate the trouble, whereas a few minutes' intelligent checking would have pointed to rear-axle defect.

Checking Axle without removing from Car

The complete axle can easily be checked without being removed from the car by first jacking up and testing the wheels. If these do not run out of truth and the axle shafts appear to be perfectly free when turned by means of the wheels, the jack can be removed after the wheels have been turned so that each tyre valve is towards the front of the car and about the same height from the ground as the centre of the wheel. The measurement between the wheels at the valves should now be taken with a track tester or suitably bent rod, after this the car should be wheeled along until the two tyre valves are at the back of the car and at the height of the wheel centre from the ground, and the measurement between the wheels at the

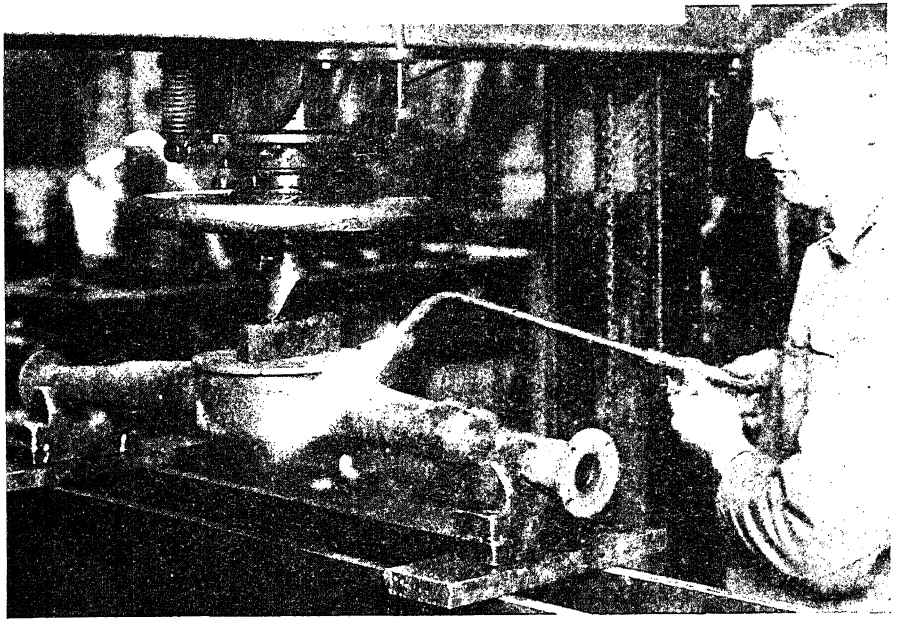


Fig. 28.—STRAIGHTENING BENT REAR AXLE CASING BY HYDRAULIC PRESS WHILE HEAT IS APPLIED

valves again taken. If this is the same as when the valves were in the front position, the axle is correct in the vertical plane (the valves are used in making these checks to ensure that the same points of the wheels are used both at the front and rear, and this makes the test accurate even if the wheels are not perfectly true).

To check in the horizontal plane, set one of the wheels vertical by means of a plumb-line. The line may be dropped from the wing and measurements taken from the rim to the line at top and bottom of the wheel; if these measurements are not equal, the axle can be suitably jacked up until they are. The other wheel should then be tested with a plumb-line and should be vertical without any alteration of the jack.

If the axle passes these tests, it is correct, otherwise it must be taken down and completely stripped out.

Straightening Axle Casing

The axle casing should then be set up in a lathe and, by means of a scribing block, the point at which the bending has taken place, located. If the casing is from a light car and the bending not too serious, it should be possible to straighten in the lathe by suitably packing under the bent part so that a lever can be used, while slight heat is applied, to spring the axle casing true. When straight, the faces to which the brake

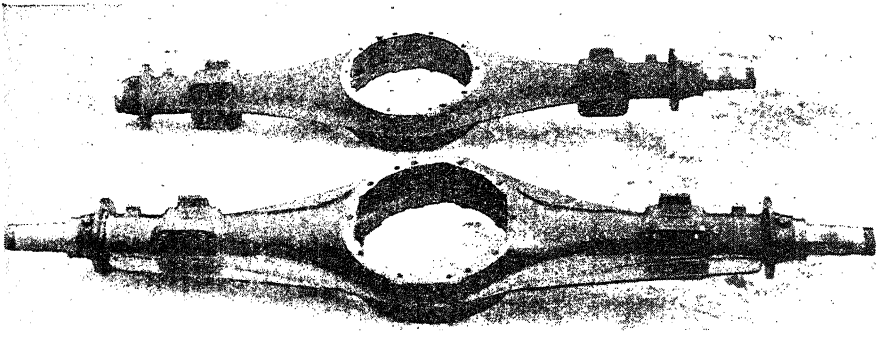


Fig. 29.—METHOD OF REINFORCING REAR AXLE CASING TO STAND EXTRA LOADING

assemblies are bolted must be carefully checked, and a slight skim taken off them in a lathe if required.

If the casing is badly bent, it will be necessary to straighten under a press, and it may be advisable to employ a specialist for the repair.

Torque Tube, Propeller and Axle Shafts

The torque tube, propeller shaft, and half-axle shafts should also be tested in a lathe, as well as the brake drums and plates.

Wheels

Pressed-steel and easy-clean wheels are usually difficult to repair with the equipment at the disposal of the average repairer, as they require to be clamped to special fittings and straightened by means of a press. It is usually possible for specialist repairers to repair them economically.

Wire wheels should be examined for loose or broken spokes, and when these require replacing or tightening, the wheel should be mounted in position on the finished axle so that the truing up is accurate. The correct tension can be regulated by the sound given by the spokes when tapped with a piece of steel.

ACCIDENTAL AND FROST DAMAGE TO ENGINES

This article would be not complete without reference to engine damage, which frequently occurs when a car is involved in an accident. Apart from this, the car is usually insured against damage due to frost, by which the engine and radiator are the principal components affected.

Accidental Damage

Accidental damage to the engine usually results in a part of the main casting being broken, such as the fan-bracket support, engine-bearer

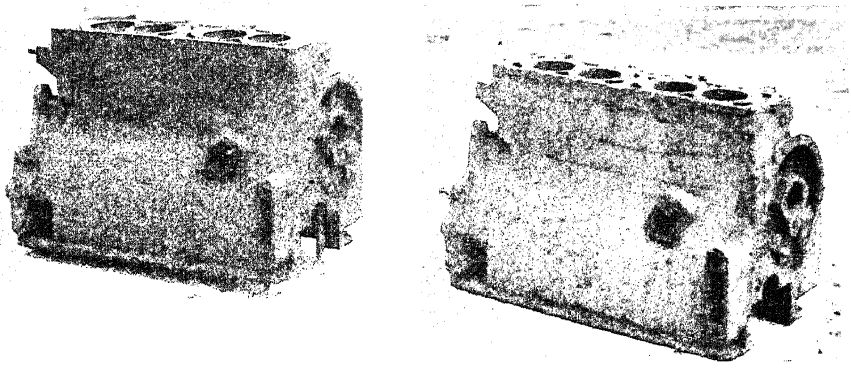


Fig. 30.—REPAIR OF CRACKED WATER JACKET OF CYLINDER BY PATENT COLD PROCESS
This repair can often be made without dismantling the engine.

supports, dynamo bracket, etc. It is possible to repair many of these breakages without completely stripping the engine, and this, of course, results in a very considerable saving in the cost of repair, quite apart from the fact that an engine which has done a considerable amount of work usually develops more noise after it has been taken to pieces and reassembled without undergoing complete overhaul.

Frost Damage

As regards frost damage, this usually results in fracture of some part of the water jacket. If this is repaired by welding, it will, in most cases, necessitate reboring and the fitting of new pistons as well as the refitting of all bearings, and this will make the repair an expensive one. On the other hand, there are now available processes for repairing cracked water jackets which in many cases

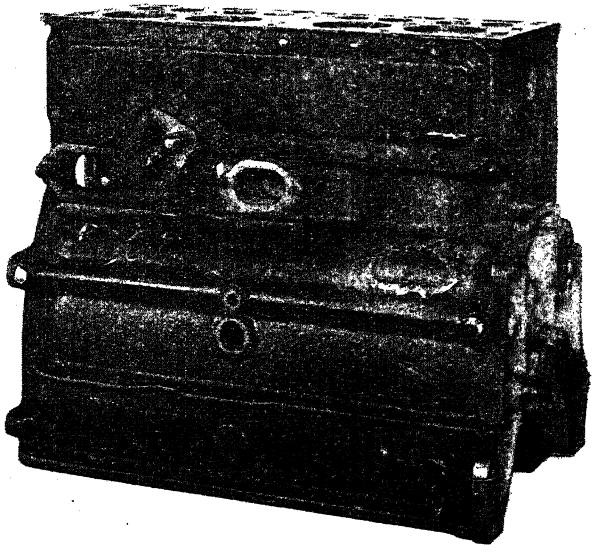


Fig. 31.—BROKEN PIECE ELECTRICALLY WELDED IN CRANKCASE

obviate the necessity of stripping the engine, thereby saving considerable time and money.

The repairer should, therefore, satisfy himself or obtain the advice of a specialist regarding the possibility of repairing the engine without completely dismantling before he proceeds with the work.

HOW TO LOCATE AND REMEDY CAR NOISES

By C. W. G. TAYLOR

ALTHOUGH it is usually a simple matter to eliminate a noise once the cause has been traced, it is often very difficult indeed to locate the defect causing the noise, even when the position from which it originates is known fairly accurately. Some of the more troublesome causes of noise are considered in detail below, and similar procedure to that recommended in these selected cases may be applied to advantage in locating other similar defects.

Doors and Windows

Rattle from the door of a car can be due to one or a combination of three defects :

(1) Glass may rattle in frames.

(2) Door may rattle bodily.

(3) The window-winding mechanism (housed inside the lower part of the door) may rattle.

The first step in tracing the fault is to close all windows tightly, and then, one by one, open each door and shake it thoroughly, and also press the glass, to detect any looseness.

If the noise is heard while the door is being shaken with the window closed and there is no sign of glass looseness, it indicates that the window-winding mechanism is the cause of the trouble, for with the door open, any knocking against the door frame is eliminated.

If the rattle is heard with the window open or partly open, but not when closed, it indicates that the glass is loose in the runners. In the event of the door not rattling when shaken either with the window open or closed, it is evident that the noise heard only when the car is on the road must be due to the door rattling bodily.

Remedy for Glass Rattling in Frame

The most usual cause of this trouble is that the rubber strips at the sides of the window become worn. These are not visible. The inside window frame must be removed by taking out the screws. The rubber strips or slides can then be seen and inspected. Sometimes a satisfactory remedy can be effected by reversing the strips from the two sides and

refitting upside down. If, however, the wear is general, and additional packing is not likely to be satisfactory, a new strip, which can be obtained from any body-builder, should be inserted.

Remedy for Doors which Rattle Bodily

The door rattle can be due either to worn-down rubber stoppers or to the door having dropped a little at its hinges. In either case the cause can readily be ascertained by inspection.

The hinges should be checked over first, as the screws sometimes work loose, causing play between the door and the frame. If this is found to be the case, the loose screws should be taken out and a little cotton-wool inserted before replacing the screws, otherwise they may very soon work loose again.

In the case of the rubbers, these are fitted just above and just below the lock catch, and are so fitted that when the door lock is on its first catch they are just touching the door, and are compressed when the door is fully shut.

If the rubber stops are found to have become permanently compressed or distorted, they can be removed and packed out to the extent necessary to provide the required pressure against the door to hold it firmly in position.

Alternatively, it may be found that the door catch requires adjustment. The catch which engages with the bolt is seldom the rigid fixture it often appears. It will usually be found that by loosening the screws which appear to secure the catch to the car the catch can be moved back as much as half an inch. This adjustment is expressly provided to restore pressure against the rubber stops after they have lost some of their elasticity.

Conversely, whenever new rubber stops are fitted to a car door, the position of the catch should be checked over and the catch moved to its most forward position, so that the rubbers are not subjected to excessive pressure, which would cause early distortion and necessitate slamming the door to engage the catch.

Defective Window-winding Mechanism

First remove the inside door handle and the window-winding handle. This is done by tapping out the small pins that hold the handles on their shafts. To locate these pins it is necessary to push the round metal casing, which is fitted behind the handle, towards the upholstery. This reveals the shaft and the pins. The panel board on the inside of the door can then easily be removed after taking out a few screws. The winding mechanism can then be seen. This mechanism is subject to two defects which can cause a rattle. The screws, securing the plate on which the mechanism is mounted, tend to work loose. This can be remedied very simply by tightening the screws which hold the plate.

The runners which travel in the slide at the bottom of the glass develop play with wear. In this case the gap in the slide should be closed up until the runners have side movement only, i.e. no vertical play and no movement at right angles to the glass. Before replacing the panel, the rollers, their spindles, and the slide should be liberally greased.

Squeak from Front of Bonnet

No fewer than seven different components can cause the same kind of noise, i.e. a squeak, at the upper part of the front of the car :

(1) Loose radiator grille.
(2) Loose radius rods.
(3) Worn bonnet webbing.
(4) Loose radiator supports.
(5) Distributor shaft running dry.
(6) Fan shaft running dry.
(7) Generator armature running dry.

Fortunately these can readily be divided into two groups, thus narrowing down the investigation. The first four mentioned above are *not* heard with the engine running while the car is stationary, whereas the last three *are* heard. No. 1, loose radiator grille, is a borderline case. Sometimes a squeak due to looseness here can be heard with the engine running and the car stationary, and this should be taken into account. Occasionally vibration can be detected with the finger tips although the squeak itself cannot be heard.

If the squeak is *not* heard with the engine running while the car is stationary the next step is to examine the radiator grille for looseness. If this is not loose, stand in front of the car and grip the radiator firmly. Now force the radiator first backwards and forwards. If this produces the squeak or lateral play is detected, it means that the radius rods are responsible. Now apply side-to-side movement. If the radiator is felt to yield, it indicates that the webbing at the front of the bonnet is defective.

In order to check the radiator supports it is necessary to lift the bonnet and grip the radiator (as distinct from its casing) and apply side-to-side movement, or in other words, attempt to rock the radiator.

Alternatively, if in the car concerned the springs or rubber blocks on which the radiator stands are easily accessible, these should be inspected to see if there is any play between the chassis frame and the bottom of the radiator.

Had the squeak been heard with the engine running it would have been a very simple matter to trace which of the remaining possible defects was the cause, for with the bonnet raised there should be little difficulty in distinguishing whether the squeak came from the distributor shaft, fan shaft, or the armature housing.

Remedy for Loose Radiator Grille

The clips on each side of the grille should be opened out to exert more pressure on the grille.

Loose Radius Rods

Unclip and raise the bonnet. The radius rods support the radiator and its casing. The rods extend from the rear of the radiator to the dashboard, and are held in position by brackets at each end through which the rods pass. The rods are threaded at each end and are fitted with nuts which pull up against the brackets and so hold the rods in tension. One or more of these nuts may have worked loose, allowing the rod to move in its brackets, thus producing the squeak. The trouble is remedied simply by tightening the nuts until the rods are held firmly against their brackets.

Defective Bonnet Webbing

Webbing is used at each end of the bonnet, at its junction with the radiator and the front of body, to prevent the bonnet from rubbing on the other surfaces. In course of time this webbing wears, and in places may be found to have worn through, thus allowing the two metal surfaces to rub together. Worn webbing at the rear end of bonnet can be detected only by close inspection. Nothing short of renewing defective webbing will eliminate the squeak.

Loose Radiator Supports

If spring mounted, remove split-pin from castle nut on holding-down bolt and tighten two or three turns until any further movement would compress the spring. On no account should the spring be fully compressed, as its purpose is to prevent road shock from being transmitted to the radiator.

In the case of rubber blocks, if these have lost their resilience, they should be removed and replaced by new ones. Insertion of additional packing is not recommended.

Distributor, Fan, and Generator

In each of these three cases the squeak is due to lack of lubrication. In the case of the shaft running through the centre of the distributor housing, the oil cap may be difficult to find as it is usually at the extreme bottom of the housing, and is protected by a spring-loaded dust cap. This cap has to be pulled back before the oil hole is visible. The cam on the distributor shaft and the pin holding the contact breaker arm should both be inspected. If these are dry they will produce squeaks. Use only light machine oil for lubricating these components. It should be applied very sparingly indeed. All the above remarks in connection with lubricating the distributor also apply to the generator.

The fan in most cases can be greased with the grease-gun supplied with the car.

Squeak from below Front of Car

In this case a different method is necessary as there are four possible causes, two of which involve a considerable amount of work. Hence

every care should be taken to eliminate the possibility of the defect being due to one of the others before investigating the two difficult defects. The following group is therefore given in order of increasing difficulty with a view to avoiding waste of time in locating and remedying the cause of the trouble.

(1) Front bumpers loose on bracket.
(2) Worn shock-absorber bushes.
(3) Defective springs.
(4) Road-wheel bearings.

It is worth while running the engine with the car stationary. Although the squeak is not likely to be reproduced it is possible that vibration due to looseness may be detected by placing the finger tips on the first two components in the above list, in which case the defect is located very rapidly indeed.

Bumpers

These are supported from the front of the chassis by brackets held in position by four bolts and nuts, which may have worked loose. To ascertain if this is the cause, stand in front of the car, grip the car bumper with both hands and lift up and down to ascertain if the bumpers move independently of the car. It will be appreciated that even a small amount of play will cause a pronounced rattle.

Remedy.—Tighten bolts and fit new spring washers if found necessary.

Water is a lubricant to rubber and in wet weather will slide back and forth and give a mysterious knock. The bolts holding the absorber to the frame often appear tight but are not when the absorber is working.

Shock Absorbers

The shock absorbers in question are of course those located forward of the front wheels. Each end of the connecting rod (which links the pivot arm of the shock absorber with the axle) is enlarged to form an eye through which there is a rubber bushing. Weather and road conditions wear these rubber bushes and allow play on the connecting rod. The rattle can be reproduced by shaking the connecting rod quite lightly.

Remedy.—First remove nuts in order to free the connecting rod. Insert new rubbers and replace the connecting rod.

Springs and Shackle Bushes

These consist of about six leaves or strips and are secured as a unit to the chassis by shackle bolts at each end and to the front axle by two intermediate U-bolts. First ascertain if the shackles at each end are adequately greased. Also examine the bushes on the shackle bolts for wear and play. Next examine carefully each leaf of the spring to ascertain if they are all sound and well greased.

Remedy.—Unless one of the leaves of the springs has developed a

fracture the remedy is simply a matter of lubrication or replacing shackle bushes. The latter will necessitate jacking up the car from the chassis behind the spring, i.e. *not* from the axle. In the case of a broken leaf the car must be jacked up exactly as explained for the shackle bush. Next the shackle bolts must be removed from each end of the spring, then the U-bolts should be removed. It is usually better to "part exchange" the old spring for a new one in preference to inserting a new leaf.

Road-wheel Bearings

If, after eliminating all other possible causes of noise from the lower part of the car, the wheel bearings are suspected, it becomes necessary to jack up the car. This should be done from below the axle. Make sure that the brakes are free. If the wheel does not spin smoothly and quietly it will be necessary to get access to the bearings.

Incidentally, if there is the slightest cause for suspecting defective bearings they should be inspected without delay, as otherwise they may cause the wheel to seize and possibly lead to a serious accident.

The outer wheel cap and then the wheel must be removed. This reveals the brake drum and hub cap. On removing this cap the castle nut on the stub axle can be seen. Remove the pin, the nut, and the washer behind the nut, and then the brake drum can be drawn from the shaft. The bearings can then be seen. These consist of two collars, one inside the other, separated by small rollers. The rollers are kept apart at equal intervals by means of distance-pieces. It is of the utmost importance that the rollers should be kept so spaced apart, otherwise they will break or become jammed.

On no account should a new roller or ball bearing be inserted in a defective or maladjusted housing.

Remedy.—It is highly inadvisable to attempt to remedy a faulty bearing. This must be removed and renewed. The defect develops mainly through lack of lubrication.

DENNIS 35-, 40-, 50-, AND 60-CWT. GOODS-CARRYING VEHICLE

REAR AND FRONT AXLES AND BRAKES

REAR AXLE

General Description

THE rear axle is a very sturdy unit and is well up to the load imposed upon it under operating conditions. Power is transmitted by a spiral bevel pinion, through the spiral bevel crown-wheel, then, by way of the differential bevel gear, to the axle shaft, hubs, and road wheels. The driving shaft of the spiral pinion is carried on two taper roller bearings which take both journal and thrust loads. It is also supported by a roller spigot bearing at the extreme end which keeps the shaft perfectly rigid.

The crown-wheel and differential gear, also the hubs, are carried on taper roller bearings. The axle shaft and hub driving flange are made in one piece. It is a floating fit in the splined differential bevel-wheel. Adjustments are provided to ensure that the driving pinion and crown-wheel teeth are correctly engaged.

Lubrication

Special precautions are incorporated to control the lubricating oil. In the past, hubs have been treated as a separate unit, but in the Dennis design the hubs are included in the axle lubricating system. This is effected by omitting the usual oil-retaining joint at the inner end of the axle tube in order to allow the oil to circulate freely through to the tubes and up to the hubs. At the inner end of the hub is fitted a special type of oil seal which prevents leakage of oil on to the brake shoes. The design takes care to limit the oil retained in the hubs by tubes, through which all surplus oil drains back into the main axle casing. At the front end of the driving shaft is another special oil-retaining seal to prevent oil leakage at this point. Gear oil only should be used in the rear axle, which holds approximately $1\frac{1}{4}$ gallons. Both ends of the brake camshaft and the fixed end of each brake shoe are carried on oil-less bearings and therefore do not need attention.

Brake Shoes

One pair of brake shoes is fitted to each drum, the shoes being operated by both hand and foot. Fuller details regarding their operation will be given in the section of this article dealing with the brakes.

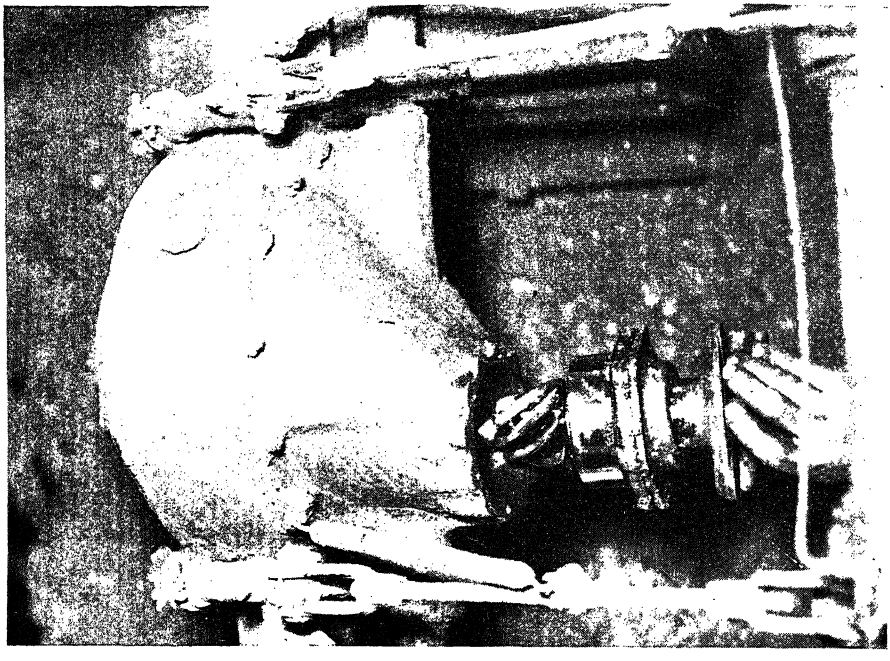


Fig. 1.—REMOVING SPIRAL PINION

Removing the Rear Axle

First disconnect the hand-brake rods where connected to the brake-operating levers, then the hydraulic expanders from the fixed bracket and operating lever (but not from the brake fluid pipe), and tie the expander up to the side of the chassis until the axle is refitted again. Next remove the bolts which connect the propeller shaft to the axle, remove the spring holding down bolts and the axle is free to be withdrawn from the chassis.

To Dismantle Rear Axle

With the axle removed complete from chassis, to commence dismantling first remove the driving hub flange nuts, then screw in the special withdrawal setscrews, which will draw out the axle shafts from the splined bevel-wheels of the differential. Having withdrawn the shafts, to disconnect the hubs lift up the tab of the locking washer, remove the locknut, when the tab washer can be taken off and the second locknut removed. The hub, together with the outer roller bearing, can then be pulled off, followed by the distance tube and the inner roller bearing, etc. Care should be taken in handling the special oil seal, because if this is

damaged in any way, leakage of oil will occur when reassembled. Furthermore, care should be taken that each oil seal is kept and refitted to its own hub if still usable, as if it is changed over it may not be effective in preventing oil leakage. If any doubt is felt at all in regard to these oil seals, it is best to replace them with new ones.

Removing Brake Shoes

The brake shoes can be dismantled by removing the fixing wire and the setscrews which secure them in position. The shoes can then be pulled off the oil-less bush which is fitted to the anchored end, while the expanding end will slide off the operating cam. The shoes are provided with inserts which can be replaced to take up any wear that may occur.

Removing the Brake Shaft

To dismantle the brake-operating shaft it is first necessary to remove the bolt on the shaft clamping clip. This will allow the cam and its short extension that fits into the splined end of the tubular portion of the shaft to be drawn out. The clip should now be driven back along the shaft towards the differential gear sufficiently to allow the shaft to pass through the cam housing far enough to let the end of the shaft come out of the oil-less bush. Now the end of the shaft should be pulled sideways away from the casing, and this will provide enough room to draw the shaft out of the camshaft housing in the spring and brake bracket.

Further Dismantling the Axle

Now it will be necessary to remove the whole of the interior differential unit, which is carried out by first removing the differential front cover, when the whole can be withdrawn without difficulty. The spiral pinion can be taken out by removing the setscrews which retain the cover plate and bearing housing in position. The primary shaft, together with its roller bearings and housings, can be withdrawn. To dismantle this unit, first remove the nut which holds the driving spider and draw this part off. The roller bearing fitted next to, and abutting on, the flange portion of the flange, can now be withdrawn by pulling off the pinion-bearing housing with bearing intact. This will leave one bearing in position, and it is important to take note at this stage of the shims for distancing out the bearing. Care must be taken that these are not lost.

Dismantling the Differential

First remove the wire, the adjusting locking ring pawl, and the nuts retaining the roller bearing cap in position. Having done this, take careful note of the exact position of the adjustment ring and *mark its position* on the fixed half of the housing. This will save time when reassembling and adjusting. Now lift the differential unit out, remove the bolts that clamp the differential cages and gear wheels, and the whole is then dismantled for attention.

Reassembling Differential

When reassembling the differential, first make sure that the differential pinion pins are clean and thoroughly lubricated and that there is no foreign matter between the faces of the cages. Make quite sure that the gear turns freely.

When mounting the crown-wheel on the cages, take particular care that no dirt is between the face of the cages and the crown-wheel face. If there is, it will probably cause the wheel to run out of truth and consequently be noisy, apart from the fact that under these conditions the wheel will work loose. Also see that all split-pins have been inserted and opened out. It will be noted that the differential cage bolts cannot turn owing to the flats fitting against the shoulder formed on the crown-wheel.

Assembling Driving Shaft

In the event of both differential and spiral shaft units having been removed, the first thing to do is to assemble the spiral pinion unit. First fit the roller bearing, with its back to the gear teeth, and then the bearing shims distance washers in position. Next fit the bearing housing over the first bearing and then insert the second bearing with its back to the spider. After making sure the face of the housing is clean, fit the washer for the cover plate.

The oil seal should next be fitted ; if there is any doubt about the one removed, it should be replaced by a new part. This should be soaked in oil before fitting. After having fitted the oil seal in position in the cover, fit this part on to the sleeve of the flanged driver. Then place the driver or spider with washer on the shaft and press home. Fit washer and nut and tighten up solid. Now hold the unit in a vice by the flange, keep the cover and oil seal close up to the spider and test the bearings for running play and adjust as necessary by the shims fitted between the two bearings.

It is important for the bearings to run with absolute freedom, otherwise crushing will result. On the other hand, there should not be excessive freedom as this will cause damage to the oil seal and also make the pinion and crown-wheel operate noisily.

Adjustments of Bearings (Later Models)

With the later models, the shaft of the differential spiral pinion is larger, and consequently the bearings are spaced more widely apart, than with the earlier type. The adjustment of bearings in this case is carried out with the oil seal pushed back against the flange of the driving flange to ensure absolute freedom when rotating the housing on the shaft driving adjustment.

To test the adjustment, with all parts in position, tighten up the nut which secures the driving spider as tightly as possible, hold the shaft in a vice in a vertical position and rotate the housing on the bearings. It

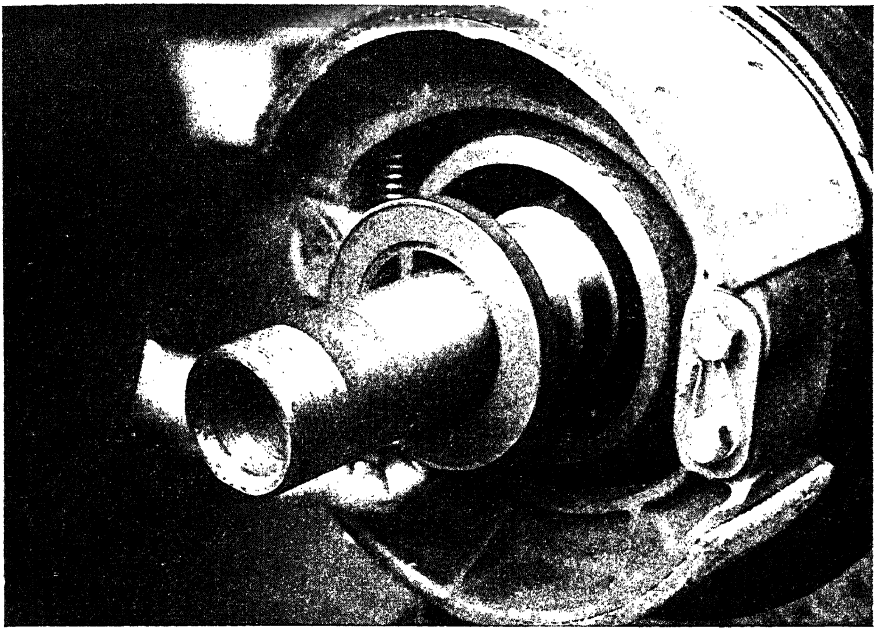


Fig. 2.—REASSEMBLING REAR AXLE HUB (1)

Placing the special oil-retaining seal in position. "Note" the lip of the leather points towards the bearing.



Fig. 3.—REASSEMBLING REAR AXLE HUB (2)

The inner roller bearing is then placed in position.

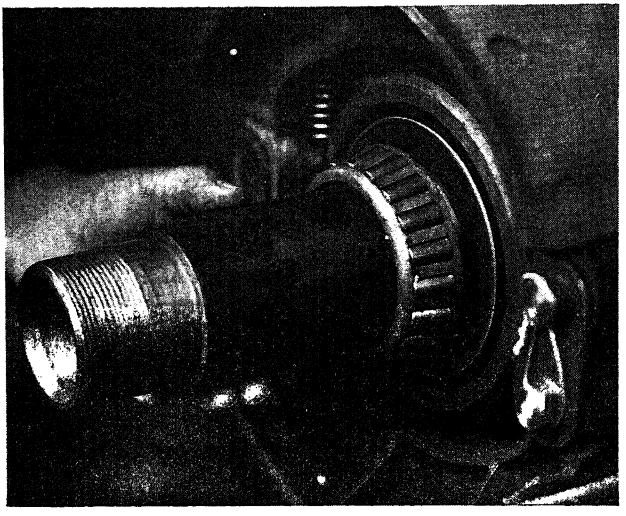


Fig. 4.—REASSEMBLING REAR AXLE HUB (3)
The distance sleeve is then placed in position.

ment depth can be adjusted by the insertion or removal of shims at the face joint of the pinion housing.

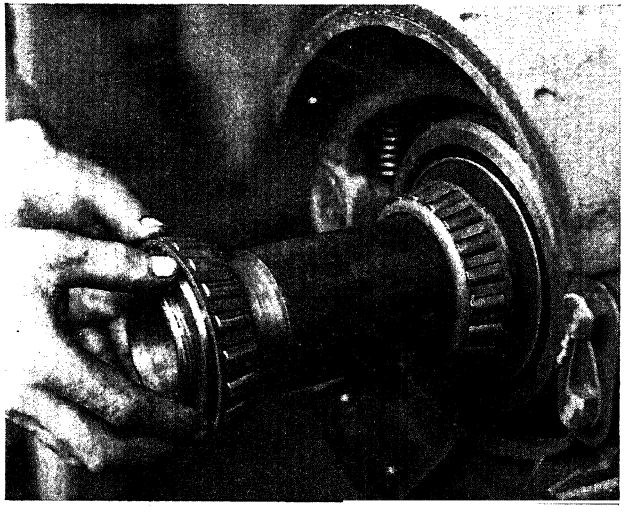


Fig. 5.—REASSEMBLING REAR AXLE HUB (4)
Showing how the outer bearing is fitted after the hub has been fitted.

should spin with absolute freedom and at the same time there should not be any end movement. If there is end movement or side play, remove the bearing shims and replace with some slightly thinner, or if the shaft will not rotate freely, then insert shims that are slightly thicker to obtain the desired results.

It should be noted that the correct tooth engage-

Fitting up the Unit

The differential pinion and crown-wheel can now be fitted in position. With the unit complete and bearings in position, their backs being towards the differential, place the unit in position to the marks previously made and fit the bearing caps, making sure that they are down in correct position on the adjusting threads. Now fit the setscrews and tighten up.

The parts should

be rotated for free running, also, the pinion and crown-wheel should be checked to ensure they are in full contact and that the ends do not overlap. There should be just perceptible play between the teeth, approximately ·004 in. After ensuring that all adjustments are completed and correct, finally make sure that all split-pins, tab washers, the wire fixing the adjusting ring, locking pawl, and the setscrews of the bearing cap are all properly secured.

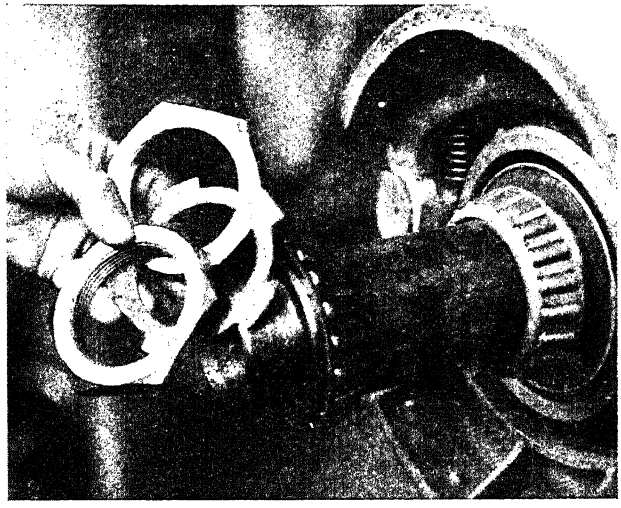


Fig. 6.—REASSEMBLING REAR AXLE HUB (5)
Showing the two locking nuts and tab washer that fits between them.

Fitting Parts in Main Cases

The unit can now be fitted to the main casing, but first of all see that the paper joint is in position and that some gear oil has been poured into the differential cages. Fit the paper joint to the rear of the case and the back cover and bolt up.

Next assemble the brake shaft with brake lever in position. Insert the splined end into the floating bush housing and then the other end in its bearing. Place the floating bush, spring, spring guide, and washer in position on the short camshaft, packed with a little graphited grease to protect the parts from damp. Then insert the shaft into the splined end of the tube, taking note that the clip bolt slot in the shaft corresponds with that in the tube, insert the bolt, and clip up tight. Now place the brake shoes in position, and when the pull-off springs are fitted the position of the brake lever should be verified. It should stand at an angle of approximately 15° behind the centre line of the shaft when held against the adjustment screw. Any alteration necessary can be made by moving the camshaft a spline either way to suit requirements.

Fitting the Hubs

The hubs can now be fitted. First place the roller bearing in the back of the hub with its back outwards, then fit the special oil seal, with the

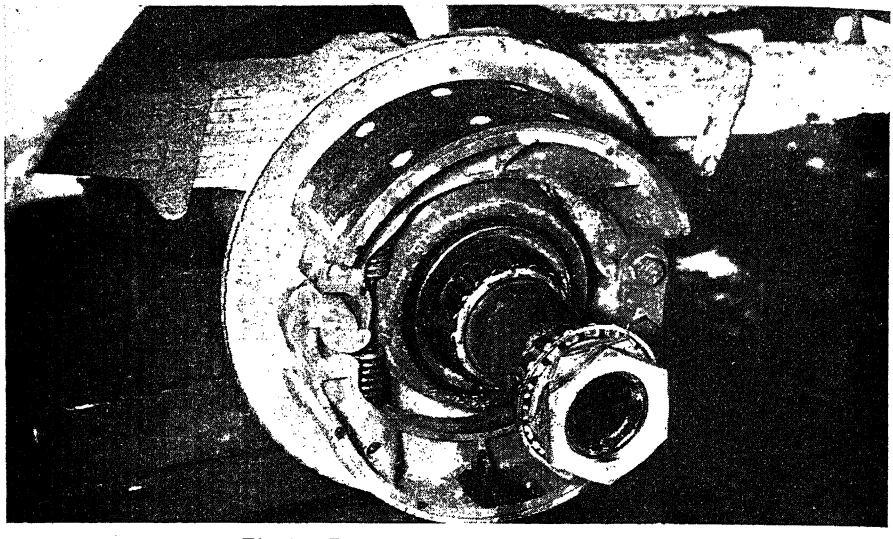


Fig. 7.—REAR AXLE HUB REASSEMBLED

edge of the pliable material towards the bearing, and insert the collar that fits inside the oil seal. Now push the hub on to the axle and fit the tubular distance piece, followed by the second bearing, facing towards the one already fitted.

Add the first locknut; tighten this up and test hub for spinning freely before fitting the tab washer and second locknut. There should be just perceptible play. Carefully double-check the adjustment and finally hammer over the tab on to the flat of the outer nut.

Fitting the Axle Shaft, etc.

The axle shafts are the next parts to be assembled. Place the paper washer on the hub face and insert the axle shaft. Bolt up the driving flange to the hub, but make quite sure that the withdrawal screws are right back and not preventing the faces coming into close contact. Half a pint of gear oil should be pumped through the special lubricator provided in each hub and ten pints in the main rear axle casing. The oil-level should be re-checked when axle is assembled to chassis.

FRONT AXLE

General Description

The front-axle design on the Dennis lightweight goods range of vehicles is somewhat unorthodox. The front-axle bearer is constructed with deep jaws at the ends. The swivel axles are fitted inside these and are so designed that the centre line of swivel passes through the centre

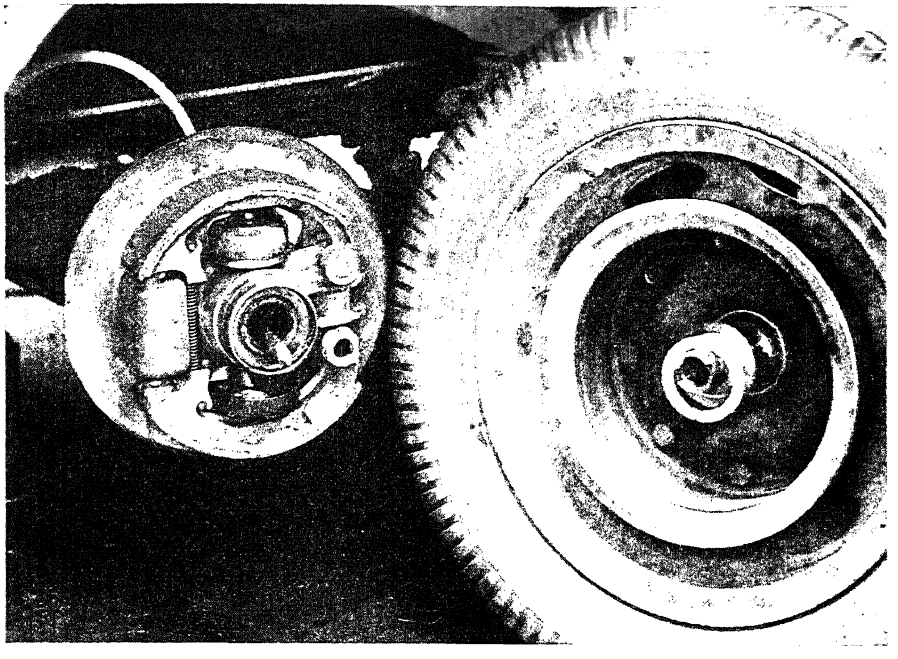


Fig. 8.—FRONT WHEEL HUB

of the tyre and gives centre point steering. The weight of the front axle is taken on a floating-bush bearing fitted into the top of the jaw. The working faces are set at an angle which makes this bearing self-adjusting. The bottom bearing is a bronze bush, closed at one end and held in position by a flange formed with the casting. It is of interest to note that there is a slight alteration of the usual order, inasmuch as the outer ring of the roller bearing is fitted in the swivel and the inner ring on the rotating axle, which is made in one piece with the nave plate, carrying the brake drum and wheel disc. The wheel studs and nuts are made with special self-locking threads. The combined nave plate and axle is held in place by a long stud fitted in the back plate, which passes through the axis of the axle and is secured by a nut retaining the axle in position.

In addition to the roller bearings mounted on the axle, there is a distance piece for adjusting the bearings, and on earlier chassis an oil circulator. The latter is in the form of rotating scoops which pick up oil from the wheel and throw it on to adjacent parts, thoroughly lubricating the bearings. Lubrication for the bottom bush is provided by way of the oil-controlled wick communicating with the oil well.

To prevent the leakage of oil from the swivels and bearings, special oil

seals are fitted and, furthermore, provision is made to prevent oil getting to the brake liners.

Brake Shoes

The brake shoe liners are $3\frac{1}{2}$ in. wide and $\frac{3}{8}$ in. thick. The shoes are operated by a hydraulic expanding cylinder situated between the ends of the shoes. The end of the shoe, which is anchored, is provided with oil-less bearings and fitted to pins located in the mounting.

Track Rod, etc.

The orthodox type of track-rod lever is eliminated from this type of chassis, the special mounting having been formed to take its place. The track-rod pin operates in a spherically shaped block, the ends of which are radiused to fit the spherical housing in the track-rod end and in which the block is a running fit. This block or centre-piece, as it is generally described, relieves the track-rod pin of any strain which may occur due to any change of angularity that takes place.

Removing Front-axle assembly from Chassis

To remove the front-axle unit complete from chassis, first take off the wheels, next disconnect the coupling bar to the steering-box at the axle end. Now undo the brake fluid pipe at the joint where it is bolted to the angle bracket fitted to the brake mounting and to prevent excessive loss of fluid fit a small plug in the end of the flexible pipe. Next tie the pipe to the chassis with its end pointing upwards and above the level of the pipe leading to the master cylinder. Finally, remove the front spring holding down U-bolts, and the front axle complete can be withdrawn.

Dismantling Axle and Swivels, etc.

Having removed the front axle complete from chassis, to dismantle the swivel axle first remove the dress-guard by taking off the nut and washer which secures same. Next remove the large nut to enable the axle nave plate and brake drums to be withdrawn. Now remove the brake shoe springs, pull open the brake shoes, and remove the hydraulic expander, the anchor pin setscrew, and the pin. The shoes can now be dismantled. Next detach the track-rod pin and steering lever, when the swivel is free for complete dismantling. Undo the setscrews which secure the flanged bush, and remove along with oil tray from the lower part of the axle jaw, when the swivel will drop sufficiently to allow the bearings to leave the housing. Now, by tilting the top of the swivel over, the whole can be lifted from the axle. Note should be taken of the packing shims located in the bottom of the bearing, which are provided to regulate the amount of end play allowed in the swivel. The remaining parts can now be dismantled without difficulty.

To Reassemble Swivel

First of all, make quite sure the swivel is quite clean and ready for assembly, then place the axle bearing at the steering lever end in position, with its back outwards. *Note* there is a difference in the shape of the ends, one being shaped to receive the oil-retaining cork washer and the other the bearing-retaining ring. Now insert the distance tube and oil circulator, making quite sure that the cup of the latter faces to the direction of rotation, and then fit the outer bearing.

Place the retaining ring, with paper washer to prevent oil leakage, in position, and the back plate fitted with the long stud. Next, position the oil-retaining cork washer with the pressed-steel backplate towards the roller bearing, fit the distance collar and oil collection cover in place and tighten the clip which secures it in position.

Fitting Swivel to Axle

The order of assembly is to first place in position the oil seal, bearing, and cover plate. Take care that the oil control wick is in position and then insert into the bottom bearing housing. Now place the distance ring in position through the hole, followed by the oil seal, and flanged bearing with its adjusting shims in position in the bottom. Lift all the parts into position and fix the oil drip tray, etc., with the setscrews, and wire these up.

The brake shoes should next be assembled in position, the anchor pins inserted, and setscrews tightened up and wired. Finally, fit the hydraulic expander cylinder and brake shoe pull-off springs.

Fitting Track Rod

The track rod should now be fitted to the steering yoke. First of all, insert the spherical centre-piece, then place the helical spring and dirt-excluding washer in position, followed by the bronze washer. Place the track-rod pin in position in the yoke and fit the track-rod pin. Make sure to split-pin the slotted nut.

Assembly of Swivel Axle and Brake Drum

After having already fitted the brake drum to the nave plate, and with the oil-retaining gasket in position, insert the swivel axle into the bearing assembly. If the distance tube has dropped, it can be lifted into correct alignment by using swivel axle retaining stud for the purpose. It is very important to make quite sure that the axle engages with the dogs cut on the backplate. After tightening up the nut which secures the swivel axle and nave plate, test the wheel for spin. *Note* this nut is not an adjustment for the wheel bearings and must be kept fully tightened and checked regularly. Now adjust the special eccentric adjustments until both brake shoes rub slightly. Turn it back until the drums revolve without rubbing, and then securely lock the eccentrics. With a paper

washer in position, the combined cover cap and steering lever can now be fitted. Check over carefully and pump in half a pint of gear and engine oil.

Front Wheel Track

Measured at equal heights from the ground, the distance between the runs at the front and back of the front wheels should be equal. A toe-in of not more than $\frac{1}{16}$ in. is permissible. The track rod has right- and left-hand threads for executing this adjustment correctly. The wheel-locks should be adjusted when the axle is fitted to the chassis, by regulating the screw which retains the cover plate in position. Packing washers under the head of the screw should be used for this purpose.

BRAKING SYSTEM

Braking is by the Lockheed hydraulic system. The Lockheed system of braking is dealt with in Vol. I. The following notes, therefore, are confined to the mechanical side of the Dennis brakes only.

Removing Master Cylinder from Chassis

First drain the fluid supply tank. To do this conveniently, disconnect the pipe at the cylinder head, depress the brake pedal slowly, allowing the fluid expelled to flow into a clean container. Repeat this performance until the tank is drained. Detach the push rod from the foot pedal, undo the three bolts which hold the cylinder to the chassis and remove the cylinders.

To Dismantle Master Cylinder

Remove the rubber foot and spring clip and stop which retain the piston, then draw the piston from the barrel. The piston cap, return spring, and check valve are then removable. Any necessary cleaning must be carried out with Lockheed brake fluid. Petrol or paraffin should never be used.

Reassembling Master Cylinder

Dip all the parts in Lockheed brake fluid. Hold the cylinder vertically during assembly. Insert the valve assembly in the large end of the spring and drop it into the cylinder. Insert the master cylinder cup and press it firmly on to the end of the spring. Replace the piston and secondary cup and complete assembly.

Front Brake Expander (Internal)

The front brake expander is mounted rigidly to the brake shoe mounting and the opposed piston acts through push rods directly on the tips of the brake shoes. The ends of the cylinder are fitted with rubber boots.

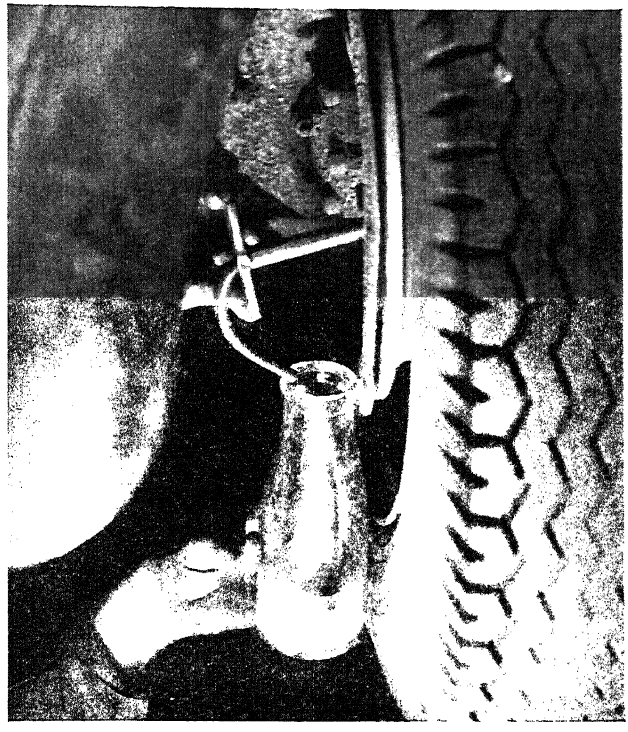


Fig. 9.—BLEEDING THE HYDRAULIC BRAKE SYSTEM

At the uppermost position and between the opposed piston is a bleeder screw. This is required for expelling all air when filling the system. To remove the front brake expander first disconnect the copper tubing from the hose connection at the axle end, then remove the nut and lock washer, when the hose union may be removed from the bracket. Fit a small wooden plug into the end of the tube to prevent the fluid escaping and tie it up with the end pointing upwards. Take off the brake drum and unhook the brake shoe return spring. Remove the two setscrews holding the cylinder to the back plate, and the cylinder can be withdrawn.

Rear Brake Expander (external)

The rear brake expanders are mounted at one end to a fixed portion of the axle and at the other end to a lever operating through a second lever, the brake camshaft. The cylinder proper is made up of a steel stamped head into which is screwed a tubular steel barrel. The joint between these two parts is made by a copper gasket. *The head and barrel must not be dismantled for any purpose whatsoever.*

Sliding in the cylinder barrel is a hollow fork-ended piston carrying a rubber cup, which acts as a pressure seal. The outward travel of the piston is governed by a screwed cap fitted on the end of the cylinder barrel. Dirt and water are excluded by a rubber boot, one end of which is clipped to the cylinder barrel whilst the other is clipped to the piston fork end. Fluid enters the cylinder head via the flexible hose attached by means of a

connection, and a bleeder screw is provided for expelling air from the pipe-line.

Removal of Rear Brake Expander

Remove the screwed plug holding the fluid pipe fitting to the cylinder head and insert a plug and tie it up with the end pointing upwards to prevent loss of fluid. Then disconnect the expander at its forked ends.

The flexible hose connections to the expanders should be examined frequently for any sign of leakage and any leaky hose replaced immediately.

Bleeding the Line

Whenever any part of the system has been disconnected it becomes necessary to " bleed " the system in order to expel all air. The supply tank should be filled with Lockheed fluid before commencing this operation and the tank kept at least half full of fluid during the whole period of bleeding. First slack back the front brake adjustment cams as far as possible, as unless this is done there is a possibility of trapping a pocket of air in the cylinder. Remove the setscrew from the end of the bleeder screw and screw in the bleeder drain, which is a special screwed brass nipple fitted with a rubber tube. Slide a box spanner over



Fig. 10.—ADJUSTING REAR BRAKE SHOES

Jack up rear axle, slacken off locknut and screw up the setscrew shown until the brake shoes just touch the drum. Slacken off to just free the drum and retighten the locknut.

the tube and allow the rubber tube to hang into a clean glass container. Unscrew the bleeder screw one turn of the spanner and depress the foot pedal quickly, allowing it to return fully without assistance. This gives a pumping action which forces fluid out at the wheel expander, carrying with it any air that may be present. Not less than ten strokes of the foot pedal will be necessary to bleed each wheel expander. Watch the flow of fluid from the bleeder drain, the end of which should be kept below the surface of the fluid, and when all air bubbles cease to appear, close the bleeder screw.

The bleeding operation must be repeated on each brake expander and the supply tank replenished each time. Should the supply tank be drained during the bleeding operation, air will be drawn into the system of this point, necessitating rebleeding.

Brake Adjustments

When the brake shoe linings have become worn to a stage where the foot pedal goes almost to the floor board, it will become necessary to adjust the brake shoes with closer relation to the drums.

Front Brake Shoes

On the mounting that also forms a cover plate for the front brake shoes will be found two screws with square heads which are fixed in position by locknuts. The inner ends of these screws are formed in the shape of a cam and press against the webs of the brake shoes. By rotating the screws by the square end the shoe can be moved towards or away from the drum.

Therefore to adjust, jack up the front axle, turn the screw until the brake shoes rub on the drums, then slacken off to allow the drum to rotate freely. Tighten up the locknut securely. Test each shoe in exactly the same way and when finished all front brake shoes will be properly adjusted.

Rear Brake Shoes

At the inner end of the rear brake shaft is a setscrew fixed in position by a locknut. It will be noted that the setscrew point presses against the lever connected to the hand brake pull-rod. This latter lever is also pushed by the head of the link which is connected to the brake expander. Therefore to adjust the rear brake, jack up the rear axle, slacken off the locknut and screw up the setscrew until the brake shoes just touch the drums. Then slacken off to enable the drum to rotate freely without rubbing. Make quite sure to tighten the locknut.

Proper Adjustment of Brake Pedal

It is important that the brake push-rod should have a slight clearance where it seats in the master cylinder pistons when in the off position. Should the push-rod be adjusted tightly against the piston, the port hole

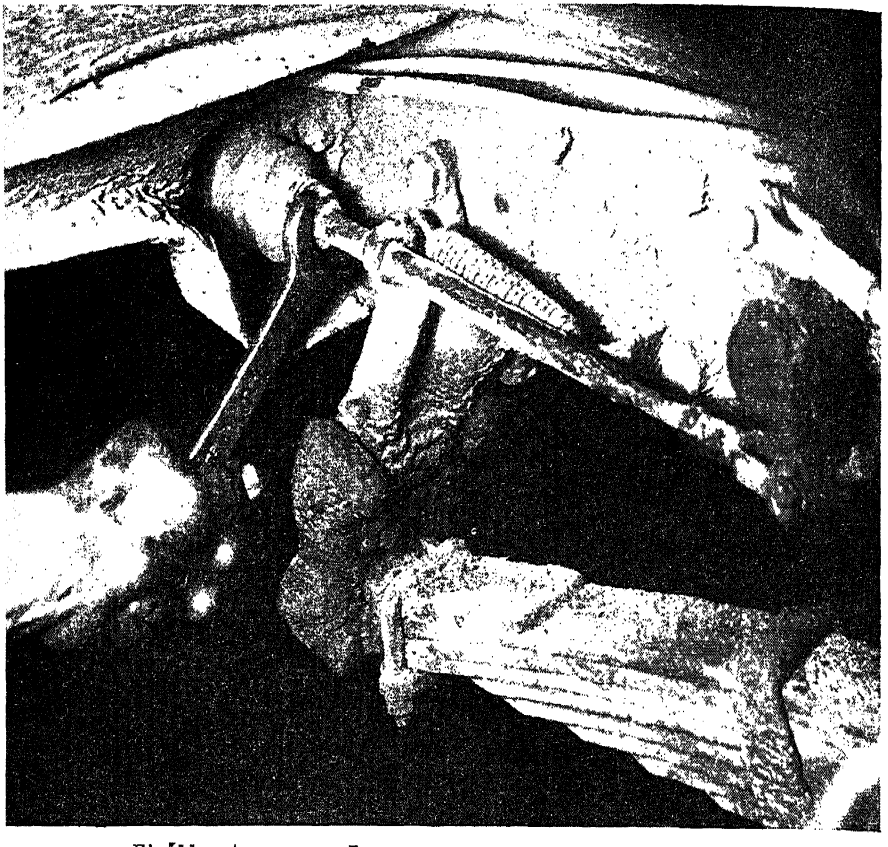


Fig. 11.—ADJUSTING LOCKHEED MASTER CYLINDER PUSH-ROD

in the cylinders will be covered by the cup washer, thus preventing the compensating action of the Master cylinder and causing dragging brakes.

Hand Brake Lever

The position of the hand brake levers can be adjusted at the fork connection on the short pull-rods. Make sure that the locknut is tightened securely, but any alteration of position due to wear of the brake linings must be corrected by an adjustment of the special screw provided at the rear brake drums.

HILLMAN MINX

REAR AXLE, FRONT AXLE, AND CHASSIS REPAIRS

REAR AXLE

THE rear axle of the 1939 Minx is of the semi-floating type incorporating a spiral bevel drive. In design it is essentially straightforward, but as the position of the crown wheel relative to the pinion requires accurate adjustment, as far as possible the original adjustment should not be deranged.

Provision is made for the adjustment of all roller bearings in the differential and bevel-pinion assembly. The complete differential unit with crown wheel and bevel pinion is detachable as a unit from the axle assembly. This should be done when it is necessary to carry out work on the differential unit.

Oil Seals

A spring-loaded leather oil seal, built up in a steel cage, is fitted just to the rear of the propeller-shaft coupling.

After a considerable mileage, it may be necessary to replace these oil seals, and it should be noted that the latest-type oil seals, made of greenish-brown leather, should be soaked in engine oil at 80° to 90° F. for two hours before fitting, if not already treated.

The cage in which these oil retainers are built is a steel pressing, and it cannot therefore be guaranteed that this will make a perfectly oil-tight fit in the recess machined for it.

Whenever replacement oil seals are fitted, therefore, the outside of the cage should be coated with a liquid jointing compound before the seal is pressed into position. These seals operate most effectively in one direction, and thus they should be fitted with the sharp edge of the leather facing the rear axle.

Hub Oil Retainers

Should leaks occur at the rear hub, before rectification is attempted steps should be taken to ascertain if the rear-hub bearings of the back axle have been over-lubricated. The retainers fitted and described later are usually adequate, but no retainer can hold back excessive quantities of lubricant.

On all hubs, front and rear, a catcher is spun on to the rear of the hub

so that the results of overgreasing are caught in these catchers, and a leakage will occur into the hub of the wheel behind the nave plate. It is obviously important that these drain holes from the catchers drilled in the hub, brake drum, and wheel should be kept clear, as otherwise the catcher may become overfilled and the grease will eventually reach the brake linings.

In the case of the rear hubs a further cup-type catcher is spot-welded to the bearing retainer plate. The edge of this cup protrudes within the catcher on the hub so that under all circumstances the grease is led away to the wheel hub without reaching the brake-shoe linings.

Two oil seals are fitted in each hub, as follows. In the axle casing an oil seal, of a similar design to that already described for the pinion housing, prevents oil from the differential passing along the shaft. The second oil seal is a felt washer built up in a pressed-steel cage, which in turn is fitted in the catcher spot-welded to the bearing retainer plate. In all cases the pressed-steel cages of these oil seals should be coated with a liquid jointing compound before fitting.

To Remove and Replace Axle Shafts

Remove the following in the order given : Road wheel, water excluder from brake backing plate, setscrews securing brake drum, brake drum, red and black springs from brake shoes, spring passing across brake adjuster.

Push the shoes outwards, and remove the three nuts securing the hub-bearing retainer plate, now push brake shoes back into the normal position.

Refit the water excluder, and replace brake drum and road-wheel nuts and tighten evenly. This will withdraw the shaft nearly out. A slight leverage placed behind the brake drum when the wheel nuts are fully tightened will completely release bearing from casing.

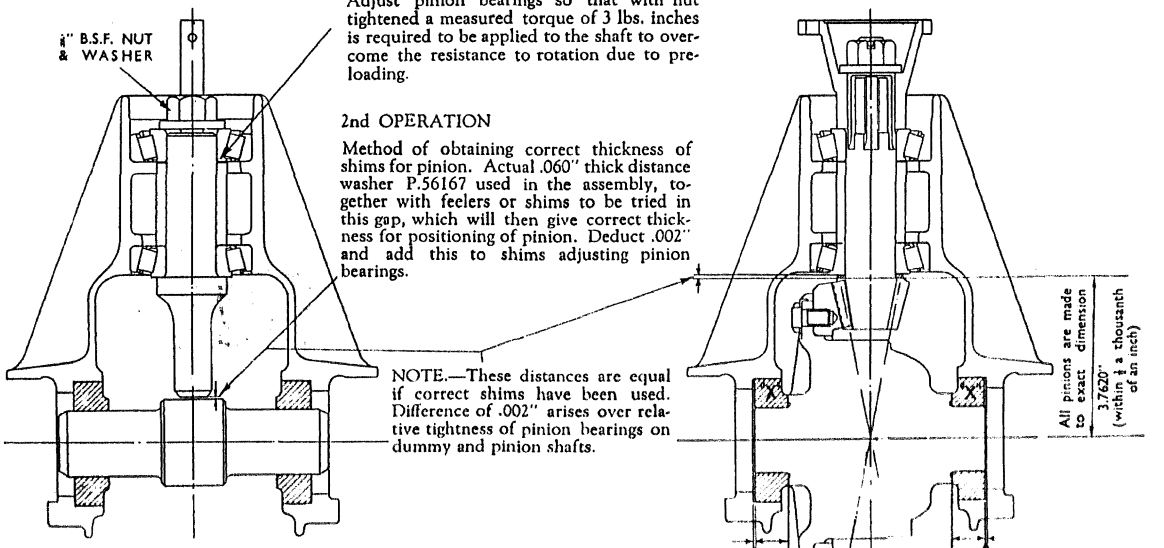
In replacing, the operation is straightforward, except that care must be taken to place the retainer plate so that the clearance in the plate for two nuts in the backing plate is opposite these two nuts.

To Dismantle and Rebuild Axle Shafts

When it is necessary to examine the oil seals, as described in the preceding paragraphs, the shaft having been removed must be dismantled as follows :

Knock down tab of lock washer, remove nut. Draw off rear-hub bearing by means of special hub-bearing drawer. The retaining plate complete with oil seal may then be taken off the shaft.

The oil seal is pressed into the cup welded on the retainer plate. It is important that the cage of this felt oil seal should fit tightly into the cup welded into the retainer plate, and jointing compound should be used on the outside of the cup.



1st OPERATION

Adjust pinion bearings so that with nut tightened a measured torque of 3 lbs. inches is required to be applied to the shaft to overcome the resistance to rotation due to preloading.

2nd OPERATION

Method of obtaining correct thickness of shims for pinion. Actual .060" thick distance washer P.56167 used in the assembly, together with feelers or shims to be tried in this gap, which will then give correct thickness for positioning of pinion. Deduct .002" and add this to shims adjusting pinion bearings.

NOTE.—These distances are equal if correct shims have been used. Difference of .002" arises over relative tightness of pinion bearings on dummy and pinion shafts.

3rd OPERATION

For obtaining correct shim thickness for positioning crown wheel:—

(a) Slip dummy bearing discs 'X' on ends of differential carrier, insert feelers at point 'A' with correct back lash between gears.

(b) Obtain distances 'C' & 'D' by adding together thickness of feelers used plus .800"

(c) Measure exact overall height of actual bearings to be used and subtract from dimensions 'C' & 'D' this will give actual thickness of shims required. Add .001" to each side.

Fig. 1.—Jigs used in adjusting crown wheel and bevel pinion, Hillman Minx

Rear-axle Breather

If at any time the rear cover of the axle is removed, it should be noted that whereas the cover is secured in most cases by setscrews, in one case a stud is used. This stud should be fitted in the hole approximately at one o'clock when the axle is viewed from the rear. An examination of the stud will reveal that it is drilled to provide a breather for the rear axle and if replaced in any other position might easily cause trouble through oil leakage.

Differential Unit

The design of this unit has been altered on the 1939 Minx with a view to providing a very much more rigid construction, coupled with special lubrication scheme which ensures that all parts are continually receiving large supplies of lubricant. On the other hand, when adjustment is necessary it can easily be carried out by the use of simple special tools obtainable through Messrs. V. L. Churchill and Co. Ltd. These tools can be used sucessfully owing to the fact that the locality faces on the crown wheel and pinion are tied to an accuracy within ·0005 in., and thus with the use of these tools the adjustment of this unit is very much quicker and surer than on any previous model.

To Dismantle Differential Assembly

When removing the differential box complete with bearings, take care that the outer rings of these bearings are not interchanged one side with another. Remove split-pin and nut securing coupling to pinion. Remove coupling. Drive bevel pinion out. It will become detached with the distance-piece and shims. This distance-piece with shims controls the adjustment of the bearings supporting the pinion.

To Dismantle Differential Box

Knock out taper pin securing trunnion shaft in differential box. Push out trunnion shaft. The trunnion wheels complete with thrust pads can then be carried round and brought out through the openings in the differential box. The axle end wheels can now be taken out of the differential box through the same openings.

The rebuilding is a direct reversal of the above.

To Assemble and Adjust Complete Unit

Withdraw rear Timken bearing from pinion shaft. Place rear bearing on dummy shaft. Place shims and distance-piece on dummy shaft. Remove oil seal from nose of casing. Fit dummy shaft into casing and outer bearing on dummy shaft. Fit coupling nut and washer and tighten fully.

Check these pinion bearings for adjustment, which can be altered by

removing or fitting shims at the end of the distance-piece between the two bearings.

When correctly adjusted the bearings should be pre-loaded, i.e. tightened beyond the normal position for free movement. The extent of the pre-load is measured by testing the torque required to turn the shaft, which should be 3 lb. in., i.e. a pull of ½ lb. on a lever arm of 6 in. The lever arm can be fitted into the tommy-bar hole in the dummy shaft, and a spring balance used to apply the load.

Having established this pre-load, fit the centre jig into the casing, using the two dummy bearings as shown in Fig. 1. A gap will exist between the end of the dummy shaft and the centre of the centre jig. The gap should be measured with feeler gauges and the original spacer washer, as shown.

The measurement taken with feeler gauges is the thickness of the shims required to be built on to the pinion shaft when reassembled. In practice, however, it is found that as the bearing is placed on to the pinion shaft it alters in length to the extent of ·002 in. This should therefore be subtracted from the thickness of the shims which would be required to fill the gap and added to the shims at the end of the distance-piece between the bearings.

Place the thick washer, *chamfer downwards*, then the correct thickness of shims on the pinion shaft. Press on the inner member of the rear bearing. Place the shims with ·002 in. added, then the distance-piece, on the pinion shaft. Refit oil seal to casing. Rebuild pinion into casing.

When fitting the oil seal the outer cage should be coated with a quick-drying jointing compound.

This completes the assembly and adjustment of the pinion.

Having reassembled the differential box, extract the two bearings and in their place fit the dummy bearings without shims.

Place the differential box carried on the dummies in the casing and fit the caps.

With a suitable length of tubing drive the dummies inwards until the correct backlash exists between the gears. (*See* Fig. 1.) Measure with feeler gauges the gaps at the points *A*.

Obtain the distances *C* and *D* by adding together the thickness of the feelers plus ·8 in., the thickness of the dummies.

Measure exact overall height of actual bearings to be used (*see* notes below) and subtract from dimensions *C* and *D*.

This will give the actual shims required, but it is advisable to add ·001 in. to each side owing to the impossibility of working to the full measurement with feeler gauges.

Make a very careful note of the above measurements.

Remove differential box from casing, place shims in position, press on bearings, replace differential box in casing, and refit caps.

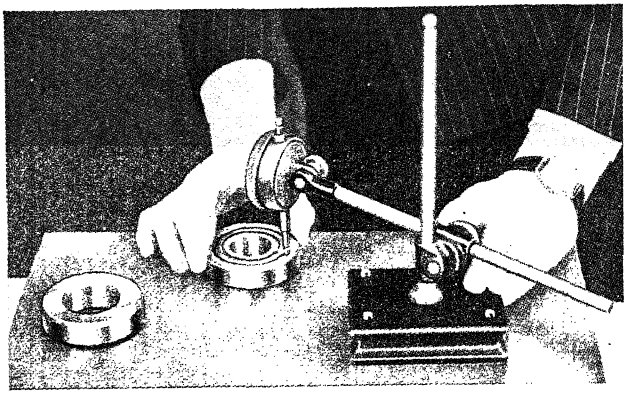


Fig. 2.—METHOD OF MEASURING HEIGHT OF DIFFERENTIAL BEARING

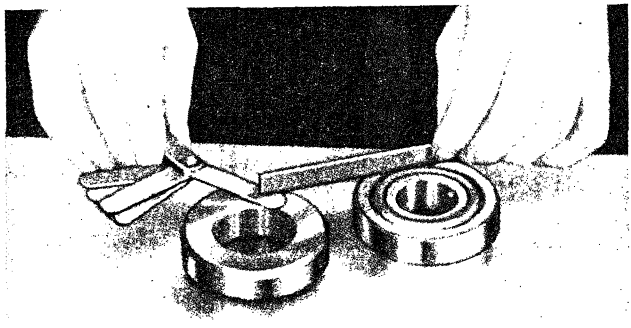


Fig. 3.—ALTERNATIVE METHOD OF MEASURING HEIGHT DIFFERENTIAL BEARING

These caps are of such a size that they give the correct pre-load to the bearings automatically.

To Measure Overall Height of Timken Bearing

This may present a little difficulty, but may be carried out by one of the two methods described below.

The first method is to use a dial gauge suitably mounted on a surface-plate and set to zero by the use of the dummy bearing. The reading then taken on the actual bearing, as shown, gives the difference.

In the absence of a dial gauge the relative heights of the bearing and the dummy can be compared with the use of feeler gauges if they are both placed on a surface-plate.

Irreparable damage will be done to the bearings if they are not extracted with the proper tools.

As pointed out in the first place, this system of assembly ensures the correct adjustment of the differential unit. If it is considered desirable to check this adjustment, it may be done by lightly coating the crown-wheel teeth with red lead or Prussian blue. It should then be revolved in both directions against the pinion, when the marking shown in Fig. 4 should be obtained.

In the majority of cases it is quite unnecessary to remove the rear axle from the chassis frame.

FRONT AXLE

In the event of a front-axle beam becoming damaged in an accident, it is strongly recommended that a reconditioned unit, which has been set

and correctly heat-treated, should be obtained from the Factory Service Department.

A taper packing is fitted between the axle and the springs. When replacing this, the thick end of the packing should be to the front.

When refitting a front axle, the U-bolts should be finally tightened when the weight of the car is on the springs.

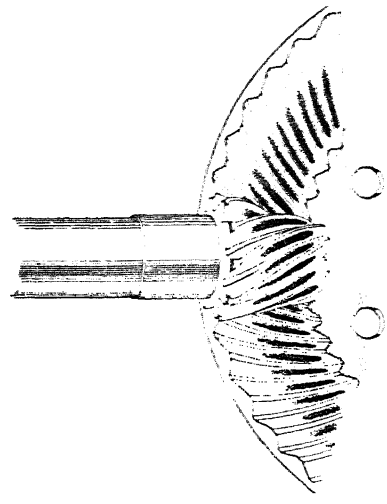


Fig. 4.—MARKING OF CROWN WHEEL AND BEVEL PINION WHEN CORRECTLY ADJUSTED

Front Hubs

It should be noted that a grease catcher is spun on the inside of the front hubs so that, should the hubs be greased excessively, the leakage which must inevitably result is caught by this catcher, the catcher being emptied through holes drilled in the hub, brake drum, and road wheel. These holes must be kept clear.

To Adjust Front Hubs

It is most important that an appreciable shake should be noticed and under no circumstances must the whole of this be absorbed. The actual measurement of the end float should be from ·010 in. to ·020 in. If necessary, remove split-pin and adjust castellated nut. Relock with new split-pin.

It should be clearly understood from the above that there can be no question of taking up front-hub bearings to eliminate any form of steering kick or wobble.

The wheel is removed so that the degree of shake can be tested accurately.

Thrust-bearing Construction

It will be noted that between the axle beam and the top of the lower swivel-pin bush a thrust-pad is fitted, made of special composition. These thrust pads should be a tight fit between the beam and the stub axle, i.e. vertically.

Wheel Alignment

Normal track adjustment is so that the front wheels toe-in to the extent of $\frac{1}{8}$-in.

The toe-in must be checked only when the wheels are pointing straight ahead. Adjust track by slackening back nuts at both ball joints and turning track rod. Relock the rod when correct adjustment has been obtained.

Steering Angles and Dimensions

As the following steering angles and dimensions are taken in some cases relative to the ground, the angles will be correct only when the car is level and is loaded to its normal static position. The latter can be ascertained by checking the spring cambers. To test the spring cambers on both front and rear springs, stretch a piece of strong thread across the centre of the spring eyes. The distance from this cord to the top of the top or master leaf is the spring camber. In the case of the front springs it should be 1 in. above, and in the case of the rear springs $1\frac{9}{16}$ in. below.

Having loaded the car to this, the castor angle can be checked. This angle is the slope of the swivel pin in a fore-and-aft direction, and is arranged so that the swivel pin is inclined backwards from the bottom. As there is no twist in the axle beam itself, the castor angle can be checked from the spring pads, and for this purpose we suggest the use of a rule exactly 3 ft. long. This is placed on the spring pads, and owing to the castor angle will lie at an incline. The distance from the ends of this rule to the ground can then be measured. If x is the distance from the rear end of the rule to the ground, the front-end height should be x plus 56 mm. Packing-pieces are incorporated between the spring and the axle to set the axle in accordance with this recommendation. The thick end of the packing should be fitted to the front.

Wheel Chamber

This is the angle of the centre-line through the wheel to the vertical. In the case of the Minx this should be $1\frac{1}{2}°$. It is felt that this can be satisfactorily tested only by the use of one of the special gauges which are marketed.

Swivel Pin

The swivel pin is at an angle sideways. This is to reduce the load on the swivel pin bearings and obtain what is known as " centre-point steering." The angle in the case of the Minx is $7\frac{1}{2}°$. Here again, one of the special gauges marketed is recommended.

Position of Ball Pin

This is a matter of extreme importance, the ball pin referred to being the one to which the push-pull rod is connected. It will be appreciated that this ball pin is so positioned that, when the axle moves, the ball pin is carried through an arc, the radius of which is the length of the push-pull rod attached to it. If the position of this ball pin is in the least upset, steering reaction, i.e. the transmission of the road bumps to the steering box and wheel, is felt. The position of the ball pin is on the centre-line of the axle beam when the wheel is straight ahead. The height of the face into which the ball pin is screwed above the face of the spring pad is 76 mm.

Steering Joints

In all four cases, the ball joints used on the track rod and at the ends of the side steering tube are entirely self-adjusting. These are of special construction and are supplied only as an assembled unit. The design is such that, provided they receive regular attention using a soft grease or gear oil, long periods of satisfactory service will be given.

If plays exists in the ball joints, this may be due to the fact that the self-adjusting mechanism has become jammed or rusted up and is not, therefore, operating. Before the ball joint is replaced, therefore, grease should be applied and the joint worked to see if the self-adjusting mechanism can be released and made to operate.

Should play exist and it is found impossible to remove it by greasing, the replacement of the complete joint will be the only cure.

CHASSIS

Bonnet and Radiator

Adjustment is provided so that the radiator shell can be positioned to fit the bonnet. This adjustment is very simply carried out. Provision of this nature overcomes the difficulties which used to be experienced when it was necessary to change a radiator or fit a replacement shell.

Slacken the three nuts securing the radiator shell to the block on each side, also the countersunk screws which pass through the lug for the bonnet hinge. Slacken the two screws securing wing to lower portion of radiator shell, one each side, and the two nuts and bolts securing wing to lower portion of radiator shell, one each side.

The shell can then be removed into any position which is desired, and thus the bonnet will fit satisfactorily.

Should it be found necessary to draw the radiator bodily towards or away from the body, i.e. to accommodate a long or short bonnet, this can be done by adjusting the two tie-rods which couple the top of the radiator to the dashpan.

Shackles

Except in the case of the front spring front shackle, the shackle bearings are composed of " Silentbloc " bushes. In the case of the front spring front shackle, the build-up is as follows : Pressed into the front-spring eye is a bronze bush. Over the shackle pin a hardened steel distance-piece is fitted, which controls the distance between the two thrust-washers which are located on the pin. When assembled, the thrust washers are nipped on to the steel distance-piece or bush so that (*a*) this steel bush does not turn on the shackle pin, (*b*) the end float on the shackle is established at ·003 in.

The " Silentbloc " bushes of patented construction consist of an inner and outer steel tube, between which rubber of special composition

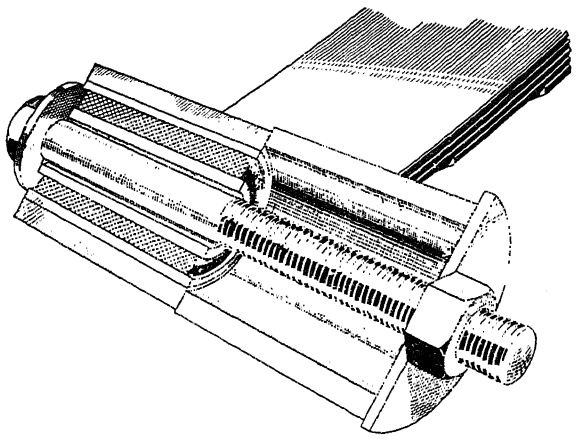


Fig. 5.—METHOD FOR REMOVAL OF BUSHES FROM SPRINGS OR CHASSIS FRAME

is arranged. In action the inner and outer tubes are held, and all movement is taken by the elasticity of the rubber.

It will be obvious that the rubber cannot stretch indefinitely, and it is equally clear that to give satisfactory results the "Silentbloc" bush should be so positioned that in service the deflections and strains imposed upon the rubber are reduced to a minimum.

To remove bronze bush from spring eye, either remove spring complete and use a press, or obtain a piece of steel tubing about $2\frac{1}{2}$ in. long, having an internal bore diameter greater than 1 in.

A bolt long enough to pass through the spring eye and this bush, and threaded for a considerable distance down its length, is also required. The bolt is then used to draw the bush into the tubing, as shown in Fig. 5.

Attention to Leaf Springs

Periodically, attention should be given to the leaves of the springs themselves, in regard to the following details :

(1) The car should be jacked up so that the weight is no longer taken on the road springs. Any road mud should be scraped off the outside of the blades and the blades thoroughly cleansed with paraffin. It will then be found possible to spray the springs with penetrating oil. This will provide a satisfactory lubricant for the spring leaves.

(2) *Alignment of the Leaves*

Periodically, and particularly when the car is new, the road springs should be examined to see that the leaves lie in line. To align the leaves, clips are riveted to certain of the blades, and these are held over the top leaf by means of a nut and bolt.

The short, lower leaves can, however, become slightly deranged. To correct this the U-bolts securing the spring to the axle should be slackened and the blades tapped with a hammer into their correct positions. Re-tighten U-bolts.

(3) After a considerable amount of usage a stiffening of the suspension system will possibly be noticeable, and this is due to the fact that the

normal radius ground on the end of each leaf is worn so that one leaf is digging into the underside of the leaf immediately above it. Such a condition will, of course, tend to damp the action of the spring.

It can be satisfactorily overcome if the springs are dismantled, the ends of the blades ground to a radius, the whole being reassembled with a liberal coating of white lead, oil, and flake graphite. Equal parts of each constituent should be taken and mixed together to the consistency of a paste.

To Dismantle and Rebuild Road Springs

Before dismantling, mark one end of each leaf with a centre punch in the case of the rear springs. This ensures that the blades are replaced in the positions occupied before dismantling, as these springs are symmetrical. Remove the spring from the chassis frame.

Hold the spring leaves together in a press and remove the dowel bolt. Release the press gradually and remove the lower leaves. Hold the upper leaves together in the press, remove the bolts from the clips on the longer leaves and dismantle the longer leaves.

To rebuild the road spring a length of $\frac{5}{16}$-in.-diameter rod should be threaded through the dowel hole before the leaves are compressed. Having compressed the leaves, the dowel bolt can then be fitted and the spring rebuilt. Before rebuilding the spring, lubricate and overhaul the leaves as recommended in notes given above.

To Replace Front Spring

Fit the bronze bush to the front end of the spring and the " Silentbloc " bush to the rear end of the spring. Both these bushes can be drawn into position by means of the long bolt from the tubular extractor, the rear " Silentbloc " bush being finally centralised by using the tubular portion as a packing piece under the nut of the bolt.

Fit the rear shackle to the spring, but do not tighten the bolt. Place the spring in position over the axle and the steel distance piece or bush in the front spring eye. Place thrust washers on either side of the front spring eye. Refit to the chassis frame. Place the shackle bolt in position and tighten the nut fully.

The end float on this assembly can then be checked. There must be no question of stiffness, but the float must not be more than ·003 in.

Build the rear shackle to the " Silentbloc " in the chassis bracket, but do not tighten the shackle bolt.

Secure the spring to the axle, fitting the rubber buffer clip under the U-bolts and the metal wedge between the spring and axle, the thickest portion to the front. Tighten the U-bolts as far as possible. Place jacks under the axle and remove the jack from below the chassis.

Load the chassis by putting excess weight on the front end. Tighten the U-bolts between the spring and axle only when the spring is fully compressed.

Release the front of the chassis frame. Obtain a length of steel to act as a gauge, measuring exactly $4\frac{3}{8}$ in. long. Other suitable dimensions would be 1 in. by $\frac{1}{8}$ in. thick. Place this gauge just in front of the U-bolt on the spring and load the chassis until this distance piece is nipped between the spring and the lower horizontal face of the frame. Only when the spring is so compressed, tighten the rear shackle bolts.

To Replace Rear Spring

Fit the " Silentbloc " bushes to both spring eyes. Fit the rear shackle, but do not tighten the bolt. Refit the spring to the chassis frame..

Place the front and rear shackle bolts in position, but do not tighten the bolts. Secure the spring to the axle.

Obtain a length of steel to act as a gauge, measuring exactly $5\frac{3}{8}$ in. long. Other suitable dimensions for this gauge would be 1 in. by $\frac{1}{8}$ in. thick. Place the gauge on top of the rear axle and load the car until the gauge is nipped between the axle and the lower horizontal face of the frame. Only when the spring is so compressed, tighten the shackle bolts.

REPAIR NOTES ON THE FIAT MODEL-500 CAR

REAR AXLE, SPRINGING, STEERING, BRAKES, AND BODYWORK

REAR AXLE

Removing Rear Axle

JACK up the rear end of the car and place supporting stands under the chassis side members. Disconnect the rear flexible coupling of the propeller shaft. Remove the wheels.

Disconnect the pin of the left torque arm ; the pin of the rear left road spring ; the fork-lever pin of left-side shock absorber ; the union of the rear hydraulic brake hose ; the pin of the right torque arm ; the pin of the rear right road spring ; the fork-lever pin of right-side shock absorber.

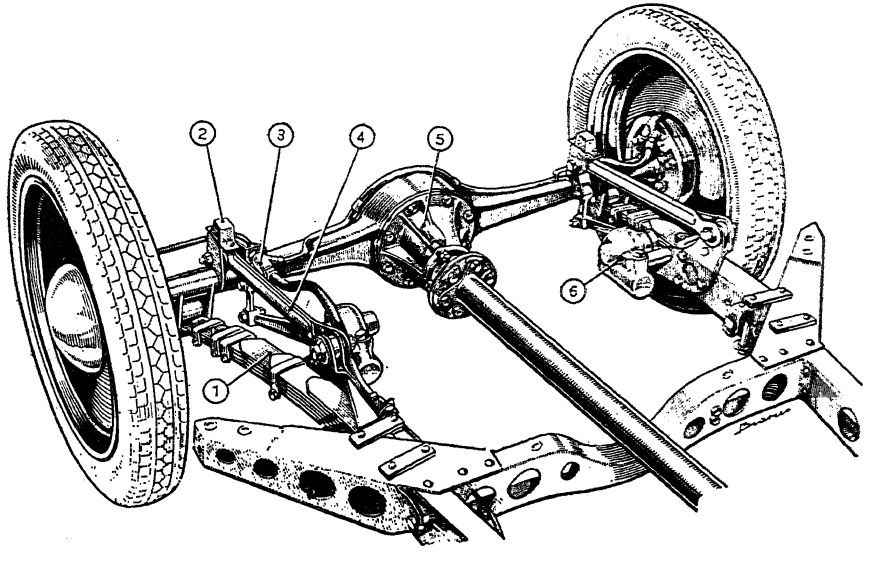


Fig. 1.—REAR OF CHASSIS UP TO CAR NO. 046000

1, Semi-cantilever spring. 2, Buffer blocks. 3, Three-way union for brake fluid. 4, Reaction and thrust arm. 5, Differential casing. 6, Hydraulic shock absorber.

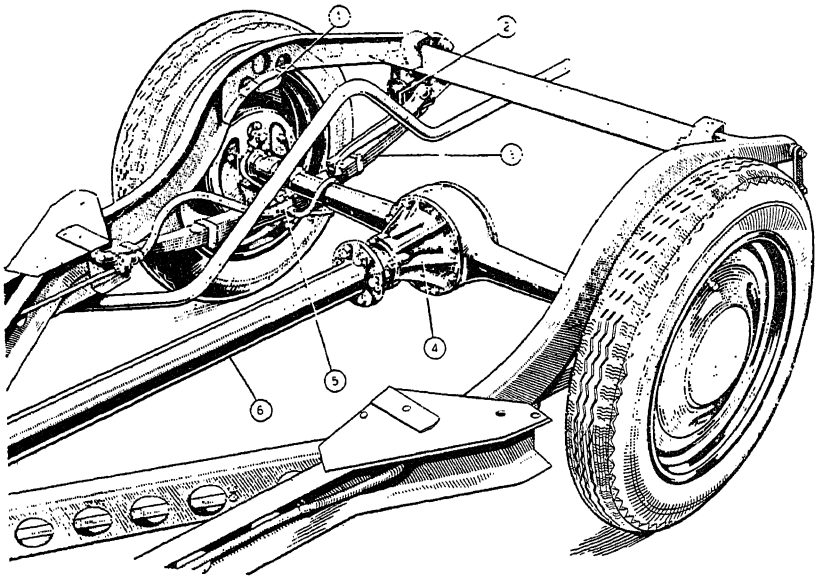


Fig. 2.—REAR OF CHASSIS (PRESENT TYPE)

1, Rubber buffer. 2, Hydraulic shock absorber. 3, Cantilever spring. 4, Differentia rrier. 5, Three-way union for the hydraulic braking system. 6, Propeller shaft.

Unscrew the bolts fixing the rear ends of the rebound straps and remove the rear axle from the car.

Dismantling the Rear Semi-cantilever Springs, with Rear Axle Removed

Up to car No. 046000, the chassis rear portion is different from that of the present-type chassis. The side members are shorter than in the present type, so as to allow the fitting of the semi-cantilever springs of the special suspension. These springs are fixed to the frame and are articulated at the end fastened to the rear axle casing (Fig. 1). Furthermore, a tubular arm, fastened to the frame and the rear-axle casing, forms a parallelogram which takes up thrust and torque. To loosen the bolts fixing the springs to the chassis side members, remove the cross-bolt supporting the front end of the spring, the spring individual packing block, and then remove the springs.

Dismantling the Rear-axle Unit

Pull off the hubs with brake drums from the driving shafts, having first removed the split-pins and the nuts, using a drawer. Remove the brake-housing flanges complete.

Pull out the driving shafts, using a drawer. Unscrew the bolts fixing the differential carrier to the rear-axle casing, and remove the differential unit.

SPECIAL REPAIR TOOLS FOR THE FIAT-500 MODEL

The following gives a complete list of the special tools available for dealing with the Fiat-500 model, including engine, clutch, and gearbox.

A. 6506. Draw bolts for the cylinder head.
A. 6507. Drawer for the valve-gear driving pinion.
A. 6508. Extension for the drawer A. 6450 for the differential driving shafts.
A. 6509. Drawer for the differential inner box roller bearing.
A. 6510. Drawer for the wheel hubs.
A. 6511. Drawer for the roller-bearing outer rings of the front wheels and propeller shaft pinion.
A. 6512. Tool for dismantling the rear-bearing inner ring of propeller-shaft pinion.
A. 6513. Puller for removing the steering arm.
A. 6514. Puller for the steering-worm roller-bearing inner rings.
A. 6515. Puller for the clutch-shaft roller bearing.
A. 8061. Spanner for adjusting the tappets.
A. 8062. Spanner for adjusting the tappets.
A. 8063. Spanner for sparking plugs.
A. 8064. Spanner for the cap fixing the dynamo driving pulley.
A. 8065. Spanner for the steering-worm thrust-bearing sleeve.
A. 8066. Spanner for the primary and direct-drive shaft locking ring.
A. 8067. Wrench for the secondary-shaft locking ring.
A. 8068. Spanner for dismantling and reassembling the starter motor.
A. 8069. Spanner for the screws that fix the fork levers on the striker rods.
A. 8070. Spanner for the wheel hub caps.
A. 10105. Lathe mandril for skimming up the front-wheel brake drums.
A. 10106. Lathe mandril for skimming up the rear-wheel brake drums.
A. 10107. Lever for dismantling and reassembling the valves.
A. 10108. Tool for fitting the pistons.
A. 10109. Tommy bar for assembling and dismantling the valve guides.
A. 10110. Tool for dismantling the steering-box oil seal.
A. 10111. Tool for dismantling the steering-box rear roller-bearing outer ring.
A. 10112. Tool for dismantling, assembling, and adjusting the clutch.

A. 10113. Ring for withdrawing the ball bearings of the differential shafts.
A. 10114. Clips for fitting the piston rings.
A. 10548. Plate for fixing the gearbox to the overhauling stand A. 10534.
A. 10549. Plate for fixing the differential group to the overhauling stand A. 10536 bis.
A. 11210. Hand-operated cylinder grinder.
A. 11439. Expanding pilot for refacing the valve seats.
A. 11440. Cutter for refacing the valve seats.
A. 11441. Cutter for reducing the valve-seat width.
A. 11443. Testing apparatus for valve leak.
A. 11444. Wire brush for the valve guides.
A. 11469. Conical grinding stone for refacing the valve seats, with the " Vibrocentric " apparatus.
A. 11475. Valve-refacing chuck for the " Vibrocentric " apparatus.
A. 11518. Blade for the IC-type " Ammco " apparatus for crankshaft-journal regrinding.
A. 11606. Chuck for refacing the crankshaft bearings.
A. 11607. Blade range for the chuck A. 11606—for refacing the rear bearing.
A. 11608. Blade range for the chuck A. 11606—for refacing the front bearing.
U. 0200. Reamer for the connecting-rod bearings.
U. 0315. Tool for valve cleaning.
U. 0326. Expanding reamer for gudgeon-pin holes.
U. 0386. Expanding reamer for the pin holes of the steering knuckles and swinging arms.

Equipments

Arr. 2009. Hook for hoisting the car both ends.
Arr. 2027. Hydraulic jack for lifting up the car.
Arr. 2205. Clips for fixing the engine on overhaul revolving stand.

Gauges

C. 641. Drum for testing the centring of the front- and rear-wheel brake shoes.
C. 642. Graduated quadrant for timing the engine.
C. 643. Gauge for the cylinder bores.
C. 644. Gauge for checking over the steering knuckle joints to the pillars.

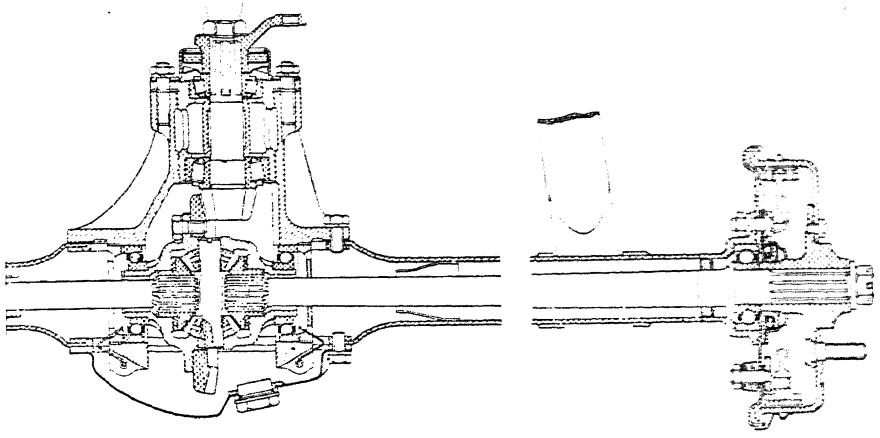


Fig. 3.—SECTION THROUGH REAR AXLE AND WHEEL HUB

Remove the split-pins and the clips of the differential assembly : the bearing caps, the locking plates, and the inner box ; the transmission-shaft rear joint ; and the bevel-pinion group.

Dismantle the bevel-pinion group ; if required, the crown-wheel, and then the planetary and satellite pinions.

To adjust the bevel-pinion roller bearings, add or remove the packing washers which are used in conjunction with distance-piece.

To move the bevel pinion backwards or forwards, add or remove the packing plates.

The side movement of the differential inner box and the bearings play adjustment are effected by actuating the locking rings after having lifted the retaining clips.

The bevel group has a toothed crown-wheel with a clockwise spiral, and a toothed pinion with an anti-clockwise spiral.

Reassembling

Repeat the same operations in a reverse order as for dismantling.

The pins of the torque arms as well as the pins of the arms of the shock absorbers must be set while the car is under static load.

FRONT SPRINGING

Removing the Unit from the Car

Remove the radiator. Jack up the front portion of the car, placing the stands under the side members of the frame.

Remove the wheels ; the pins of the semi-elliptic spring ; the four bolts fixing the spring central clamps ; the four bolts fixing the wings to

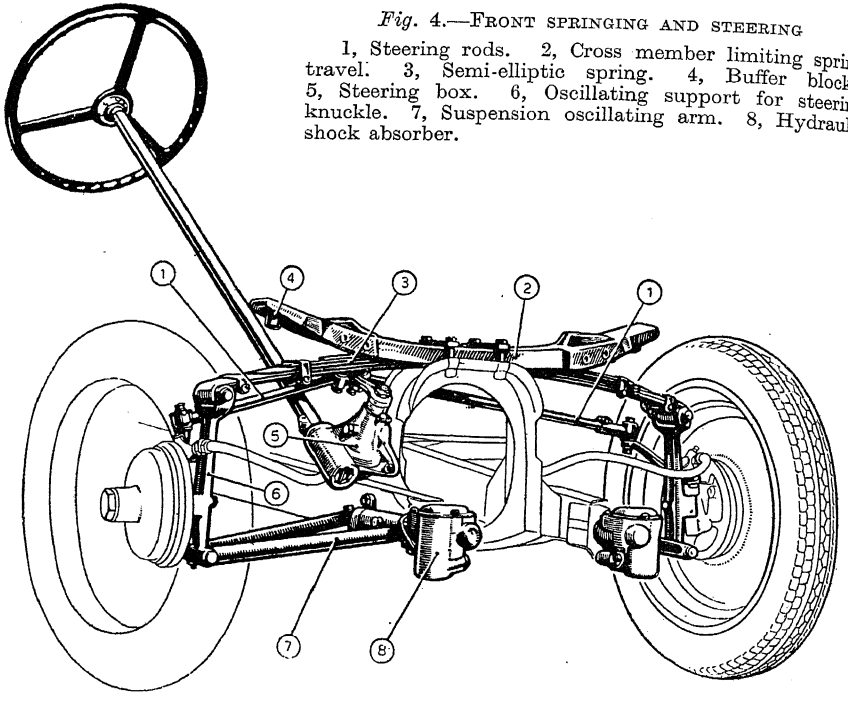


Fig. 4.—FRONT SPRINGING AND STEERING

1, Steering rods. 2, Cross member limiting spring travel. 3, Semi-elliptic spring. 4, Buffer blocks. 5, Steering box. 6, Oscillating support for steering knuckle. 7, Suspension oscillating arm. 8, Hydraulic shock absorber.

either side of the buffered cross-member ; the two bolts with spacer fixing the cross-member to the side members of the frame ; and the cross-member with the spring.

Disconnect the steering rods from the steering knuckles ; the unions of the control pipes of the front hydraulic brakes ; and the swinging-arms unit, the wheel hubs, the hydraulic shock absorbers, etc.

Dismantling the Front Springing Assembly

Remove the wheel hubs with brake drums. Later, if it is necessary dismantle the roller bearings outer rings.

Dismantle the brake-housing flanges, complete, unscrewing the bolts by which they are fixed to the steering knuckles ; the steering rods, and disconnect them from the steering knuckles.

Withdraw the steering-knuckle pins, after having removed the split-pins from the pillar ; the pins connecting the pillars of the swinging-arms unit to the swinging arms ; and the pins of the swinging-arms supports on the side members of the chassis frame.

Reassembling

Repeat the operations in reverse order as described for dismantling.

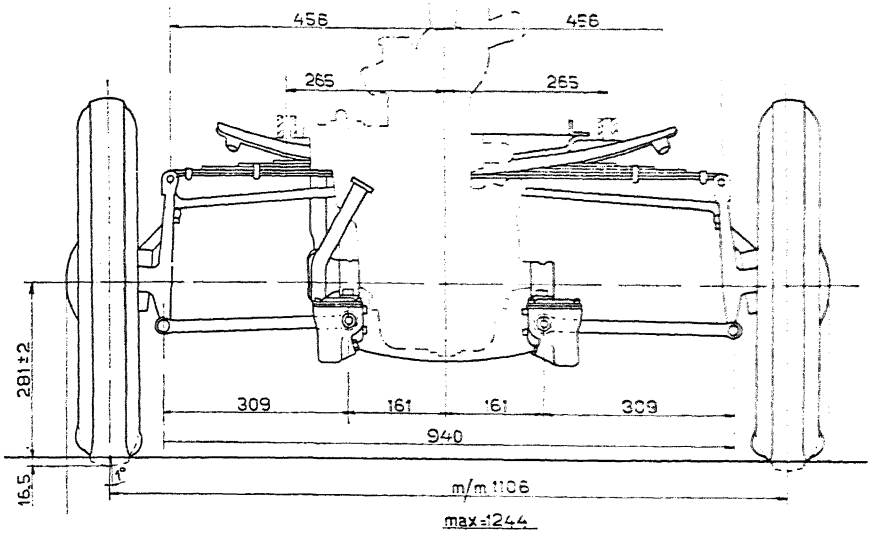


Fig. 5.—FRONT VIEW OF THE FRONT SPRINGING, SHOWING DATA FOR CARRYING OUT THE PRINCIPAL TESTS TO BE PERFORMED WITH THE CAR UNDER STATIC LOAD

Track 1,106 mm. (3 ft. $7\frac{1}{2}$ in.). Maximum width of chassis, 1,244 mm. (3 ft. $11\frac{1}{2}$ in.)

STEERING KNUCKLE AND FRONT SUSPENSION PILLAR

Make sure that the clearance between the bush located in the knuckle and the pin does not exceed 10 mm. (·004 in.).

Between the knuckle and the pillar, with their distance- and thrust-rings, the play should not exceed ·15 mm. (·006 in.).

The checking over of the suspension pillar is particularly important. Even small pillar deformations may noticeably influence the inclination of the wheels.

Checking over the " Toe-in " of the Front Wheels

Measure the distance between the insides of the front wheels from tyre edge to tyre edge both in front and behind their centres. The distance behind should be the greater by a margin of between ·12 in. and ·16 in. (3 to 4 mm.).

This test should be carried out with the car under static load.

To adjust the wheel convergence, disconnect the longer steering rod, and vary its length, according to requirements, by adjusting the sleeves at the ends.

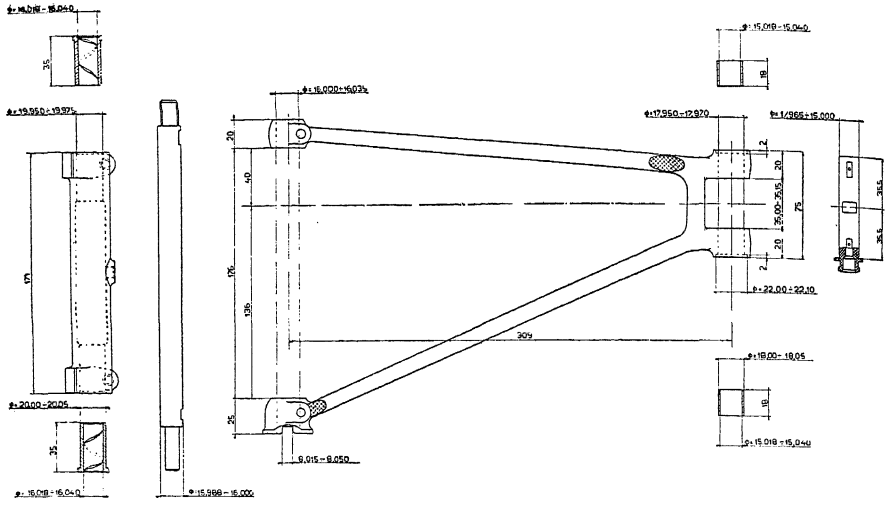


Fig. 6.—MAIN DATA FOR CHECKING OVER THE FRONT SUSPENSION SWINGING ARMS WITH THEIR PINS AND BUSHES

See that the pins are exactly parallel and lie in the same plane. The maximum clearance allowable between the bushes and the pins is 0·15 mm. (·006 in.).

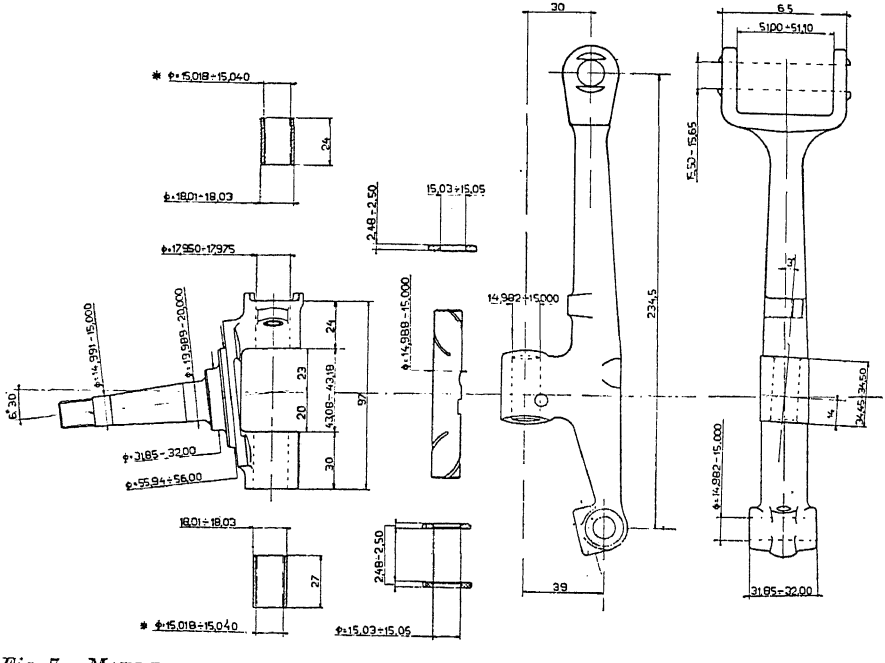


Fig. 7.—MAIN DATA FOR CHECKING OVER BOTH THE STEERING KNUCKLE WITH ITS PIVOT PIN AND THE FRONT SUSPENSION PILLAR

Checking over the Inclination of the Front Wheels

The front wheels have an outward inclination of about 1° from the vertical, which is equal to approximately ·12 in. at the tyre edge. Checking must be carried out with a laden car.

Should an undue inclination be observed, check over the whole of the front suspension, about which are supplied data with the figures.

The angle of the car longitudinal pitch should be 9°. Should there be any doubts of this, check over the individual parts of the suspension.

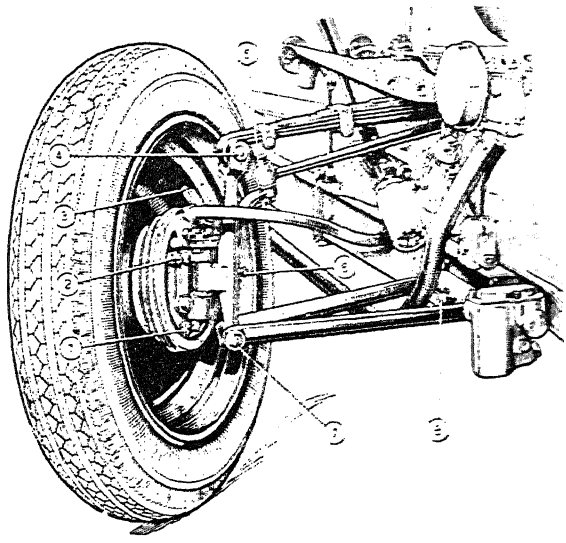


Fig. 8.—Detail of one front wheel

1, Cam for adjusting clearance between brake shoe and drum. 2, Bleeder screw in hydraulic brake-fluid piping. 3, 4, 5, Grease-gun nipples. 6, Brake-shoe pivot pin. 7, 8, Grease-gun nipples.

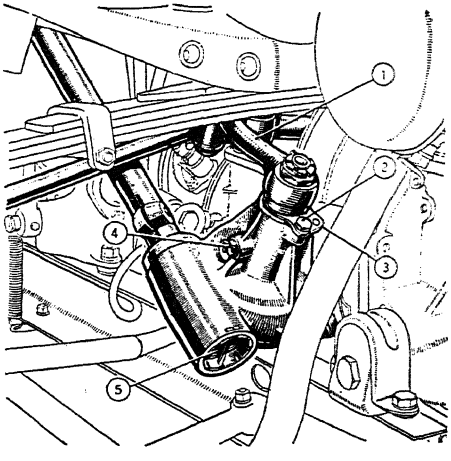


Fig. 9.—Adjustment of steering worm gear

1, Steering arm. 2, Screw holding adjusting plate in position. 3, Adjusting plate for play between quadrant and worm. 4, Grease-gun nipple. 5, Ring for regulating play in worm roller bearings.

STEERING RODS

One of the two steering rods—the longer one—has adjustable terminal sleeves, which can be unscrewed or screwed up to adjust the front-wheel convergence.

Inspect the condition of the ball joints and the concave bearings. The working surfaces should be quite smooth, without pits or roughness. Should they not be so, they should be replaced by new ones. The ball pin should also be replaced if the head tends to become oval owing to wear, or if the pin-threaded portion appears worn.

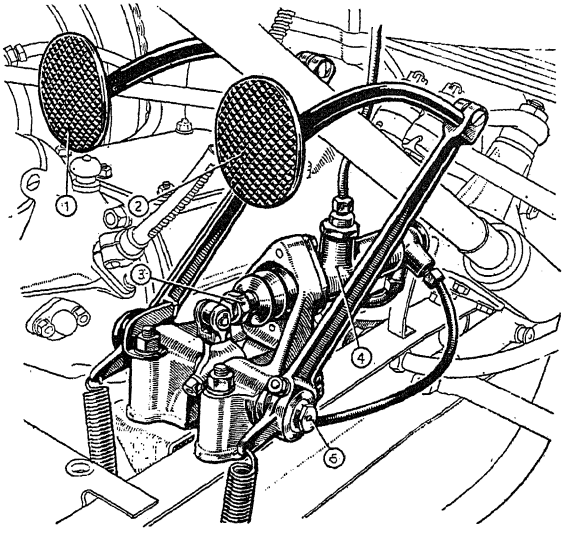


Fig. 10.—DETAILS OF PEDALS AND HYDRAULIC BRAKE CYLINDER

1, Clutch pedal. 2, Hydraulic brake pedal. 3, Nut and locknut for adjusting hydraulic brake-cylinder piston tappet and consequently the free travel of the brake pedal. 4, Hydraulic brake master cylinder. 5, Grease-gun nipple.

Also make sure that the springs still retain their tension, otherwise they should be replaced with new ones.

STEERING

Removing the Steering from the Car

Jack up the front end of the car. Remove the left-side front wheel; the engine left-side under-tray; and the split-pin and the nut fixing the steering arm. Pull off the steering arm.

Dismantle the steering column together with the steering wheel, disconnecting the electric-horn cable and removing the worm sector fixing bolt, together with the cap of the support securing the steering column to the fascia board. Remove the steering unit from the car.

Dismantling the Unit

The operations for dismantling the unit are quite simple, and the work may be rendered easier by using special tools.

Inspections and Adjustments

Closely inspect the working surface of steering worm and worm sector, which should be perfectly smooth, having no pits nor roughness.

It is also necessary to make sure, from an examination of the worm and teeth contact surfaces, that the steering worm and worm sector engage in a proper and central position in order to be able to effect the required adjustments when reassembling.

Check over the play between the eccentric bush and the worm-sector spindle. It is allowed a maximum play of ·10 mm. (·004 in.).

Make sure that the steering worm is running true: the maximum allowable tolerance is ·05 mm. (·002 in.).

Excessive play between the steering worm and worm sector is

corrected by turning the eccentric bush carrying the sector spindle, proceeding as follows:

Take down the steering arm and its packing.

Remove the screw holding the adjusting plate, turn the eccentric bush by means of the adjusting plate so as to bring the sector nearer to the worm and at such an angle as to make it possible to fix the adjusting plate again through the second hole.

Should the adjusting plate be already fixed at the second hole and consequently, by turning it, it is no longer possible to fix it in position again, it must be taken off the bush and replaced one notch farther round.

Play in the roller bearings of the worm is taken up by means of the screwed ring situated on the end of the steering box.

Should the steering worm and worm sector not engage centrally, it is possible to move the worm-sector spindle sideways by adding or taking off distance-rings on the eccentric-bush union, after which the lateral play can be adjusted by means of the square-headed screw.

The foregoing adjustments must be made in such a manner as to eliminate all play in the steering column, without, however, making the steering too stiff.

RADIATOR

Removing the Radiator from the Car

Take off the shell with the front grill. Open the tap located on the cylinder-block front, to drain the water from the radiator and the cylinder-block jackets. Disconnect the rubber hose for the radiator water inlet and outlet. Remove the bolt fixing the tie-rod on the upper part of the radiator and the two bolts fixing the lower part to the chassis cross-member. The radiator is then free and can be removed.

Repairing the Radiator Core

It is easy to detect and repair leakages in the outer-range tubes, but it is not so easy to find the exact spot where the leakage originates with inner-range tubes, so that it is sometimes advisable to substitute a new radiator core.

To eliminate small leakages, heat the part concerned with a blow-lamp, taking precaution to keep the flame moving to avoid burning the pipes. It is thus possible to create an opening among the blades, bending down the lower ones and lifting the upper ones around the leakage which is then exposed to view, and the faulty tube can be repaired.

For radiator outer repairs any soldering iron can be useful, but for repairs to inside tubes a small soldering iron, flat enough to pass between the tubes, should be used. The surface around the leakage can then be tinned, and the leak repaired. The spot to be soldered should be previ-

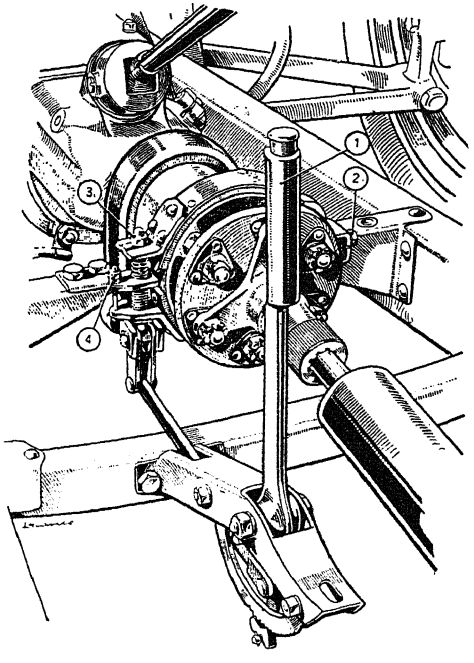


Fig. 11.—TRANSMISSION BRAKE

1, Control lever. 2, Screw for centring brake band. 3, 4, Nuts of pull rod for adjusting clearance between brake band and drum.

ously cleaned with acid. The soldering apparatus or the iron should be used moderately hot, and should be withdrawn early enough to prevent its adhesion to the tubes.

For these repairs 50/50 solder preparations should be used. (Tin and lead to be united into alloy should be first-fusion metals, without any traces of antimony or other impurities.)

When the soldering has been effected, the blades should be straightened.

BRAKES

The wheel brakes are of the hydraulic Lockheed type, and are controlled by the brake pedal. The transmission brake is composed of a drum and band, and is controlled by a hand lever.

Inspections and Adjustments

With regard to the wheel brakes, make sure that the drums are well centred; the maximum tolerance allowed being ·10 mm. (·004 in.).

As to the transmission brake drum, it should be perfectly centred and balanced. Between drum and brake band there should be an equal clearance all round, measuring about ·50 mm. (·02 in.).

The brake-shoe pivots are not eccentric, so that any necessary adjustment to the shoes should be effected through the upper eccentrics, and the clearance between the drum and the linings brought to about ·25 mm. (·01 in.).

If for any reason the free movement of the pedal is less than ·24 to ·27 in. (6 to 7 mm.), adjust the push-rod clearance by means of the adjusting nuts.

The adjustment of clearance between the transmission brake drum and the brake band is made by first using the screw shown on the right side of Fig. 11, and then on the pull-rods shown on the left of the same figure—at the ends of the brake band.

BODY OVERHAULING

Removing from the Chassis

Remove the front of bonnet, with grill of dummy radiator shell ; the front curved member, connecting the front wings. Drain the radiator and cylinder-jacket water. Dismantle the carburettor, disconnecting the starting-device control wire, the petrol pipe, the accelerator control rod, and loosening the nuts which fix the carburettor to the manifold. Disconnect the oil-gauge pipe from its union on the crankcase.

Remove the radiator. Disconnect the starter-motor switch wire. Jack up the front end of the car. Remove the left front wheel.

Disconnect the hydraulic brakes master-cylinder pipe, taking care to collect the brake fluid in a vessel ; the engine side undertrays ; and the speedometer cable from the gearbox.

Remove the clutch and brake pedal-actuating lever, and the transmission brake-control hand lever. Disconnect the clutch control rod. Unscrew the gear lever. Remove the steering column and wheel.

Disconnect the battery ; the headlamp, tail- and signal-lamp cables ; the dynamo and starter-motor cables ; and the ignition distributor leads.

Fit the left front wheel, lower the front end of the car, and jack up the rear end.

Disconnect end of the bodywork retaining fabric (i.e. rebound straps) so that the rear axle becomes free. Lower the car. Remove the seats. Pull out the carpets.

Remove the bodywork inner side coverings under the dashboard. Loosen all the bolts fixing the bottom floor framework to the chassis and those fixing the bodywork to the side brackets. Lift up the body slowly, taking care that no fixing bolt has been overlooked.

It is possible to lift up the body by hand. Four men are enough.

Reassembling the Body on the Chassis

Place the body on the chassis, taking care that the bolt holes register correctly and that the tarred-hemp pads are in their proper places. Then insert all the bolts without tightening them thoroughly. Insert the four bolts fixing the body on the cross-member and those two for which a distance-piece is supplied with each.

Jack up the front end of the car to fix the body on the front brackets after fitting the distance-pieces. Then jack up the rear end of the car to fix the body on to the rear brackets. Connect the rebound straps. Lower the car. Tighten all the fixing bolts. Fix the carpets, the inner side coverings of the body, and the seats ; the front curved member connecting the front wings.

Jack up the front end of the car. Disconnect the left front wheel. Connect the brake pipes to the master cylinder. Fit the brake and clutch-

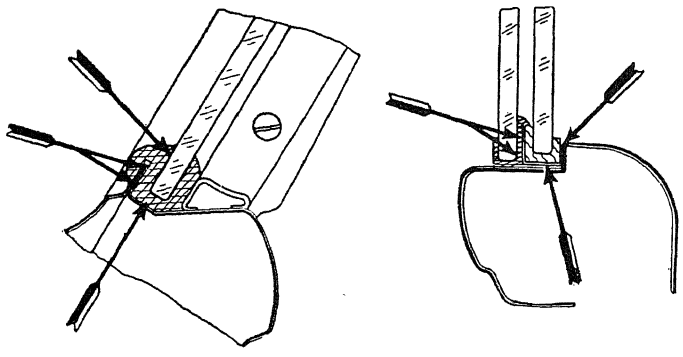


Fig. 12.—THE ARROWS INDICATE THE SPOTS TO WHICH THE CEMENT SHOULD BE APPLIED IN ORDER TO ELIMINATE WATER LEAKAGES

pedal levers; the steering column and steering wheel, and the transmission brake and the gear lever.

Refit the left front wheel, and then lower the car. Fit the radiator, and the carburettor, together with the control rod and the petrol pipe.

Reconnect the oil-gauge pipe ; the starter-motor control cable ; the speedometer cable to the gearbox ; the battery, connecting again the dynamo, starter motor, headlamps, tail and signal lamp, and the ignition distributor leads.

Bleed the hydraulic brake system.

Make sure that everything is in order, then refill the radiator and the brake-fluid reservoir. Fit the front of bonnet.

POSSIBLE TROUBLES WITH SALOON-CAR BODYWORK

Water Leakages

Water leakages in a car may originate from :

(*a*) Cement drying too quickly or from an imperfect adhesion of the framework to the channels, particularly at the lower corners of the front or rear glass frameworks. (The latter applies only to fixed-head saloons.) Water leakages may occur, too, between the door panels and the channels of the fixed or movable glasses.

Remedy.—Find out the exact leakage spot, bearing in mind that the leakage may originate in quite other places than those apparently concerned. Then apply some cement—as indicated by the arrows on Fig. 12—and make sure of the perfect adhesion of the framework.

(*b*) A deterioration of the rubber packing of the windows, probably brought about by the petrol used in cleaning the glasses.

Remedy.—Replace the rubber packing.

(*c*) Water leakages may also occur between the dashboard and the front side panels of the bodywork, as the water may come in unimpeded through the ventilation slots in the upper flaps of bonnet.

Remedy.—In the outer and lower corners of the dashboard, at the connection with the panels, there are points where filling-plaster is used

instead of rubber packing. Make sure that the plaster is still in place and not cracked or chipped. If found to be faulty, apply a new filling plaster.

Noisy Doors

Door rattles may be traced back to :

(*a*) Registers being loosened, not aligned, and not fitting in their housings.

Remedy.—Tighten the screws fixing the door registers or replace them with oversize ones if their seat thread has become worn. Under the steel housing of the rubber blocks in the striker plate add—as required—taper or flat pads to re-establish the alignment.

(*b*) Unequal clearance between door and door frame.

Remedy.—Make sure that there is a 3-mm. ($\frac{1}{8}$-in.) minimum clearance all round between the door and the door frame, both internally and externally.

(*c*) Excessive play in the latch.

Remedy.—Particularly correct the play between the latch tongue and the lock wall, punching the latter as necessary.

(*d*) Excessive play between the latch tongue and the rear wall of its catch-plate.

Remedy.—Replace the catch-plate with another 1 or 2 mm. (·04 in. to ·08 in.) longer—according to need.

(*e*) Rubber buffer at bottom of rear pillar insufficiently compressed when the door is closed.

Remedy.—Add a rubber or metallic washer under the buffer, or substitute a harder or slightly higher buffer for the old one.

Noisy Windows

The door windows may become noisy for the following reasons :

(*a*) Excessive play between the glass and its felt channels, owing to the felt getting worn.

Remedy.—Replace felt channel altogether.

(*b*) Excessive play between the glass and the felt channel, owing to the metal framework of the channel being too wide.

Remedy.—Press the edge of the metal channel slightly downwards, from inside the car, taking care that the surrounding framework is still adhering to it.

(*c*) Excessive play between the glass and the upper and lower channels.

Remedy.—Add cardboard or fibre packing between the channel and the door rail.

(*d*) The sliding glass knob becoming slack.

Remedy.—Add leather or imitation-leather washers, so glued that they register it properly on the guide. Then tighten the screw securely.

(*e*) The glasses rattle against the heads of the channel fixing screws.

Remedy.—Try countersinking the screw heads, so that these remain

completely sunk in the felt. But if the felt gets irreparably damaged replace the channel completely.

Squeaking

Squeaks may emanate from :

(*a*) The flaps of the bonnet against the edges of the cowl.

Remedy.—Reduce the height of the flap flanges to correspond with the cowl closure edges, and fit below some rubber buffers or one or two 1-mm. washers.

(*b*) The dummy-radiator shell.

Remedy.—Find the spot where the edges of the dummy-radiator shell overpass the rubber packing touching the bodywork, and remove some of the material.

Dust Penetration

The penetration of dust may be caused by :

(*a*) The rubber draft excluder which runs round the door frame having got out of shape or loose.

Remedy.—Replace the rubber draft excluder with a new one having a wider projecting rim.

(*b*) The rubber draft excluder may have too much of its rim cut off along the bottom for draining the water.

Remedy.—Remove the lower part of the rubber draft excluder and replace it with another on which less of the rim has been removed.

(*c*) The sound-absorbing plaster has come off along the lower union flange of the bodywork.

Remedy.—Remove the carpets, so that it is possible to find out exactly where the dust gets in. Then fill up with filling-material or glued strips of imitation leather.

Doors Open while the Car is Running

(*a*) Latch alignment defective.

Remedy.—Loosen the screws, align the latch, and then tighten the screws.

(*b*) Excessive clearance between the latch and the catch-plate.

Remedy.—Add a packing plate 1 mm. thick under the catch-plate.

Jacking up the Car

To jack up the car, special hooks have been devised—Arr. 2009—which are applied to the tyres and then hoisted by means of a crane. These hooks are of use in jacking up the front as well as the rear end of the car.

After having lifted the car, place stands under the side members of the chassis frame.

LEYLAND VEHICLES

PROPELLER SHAFT OVERHAUL

When removing Gearbox

TO swing the front propeller shaft aside when removing the gearbox, uncouple the front coupling from the gearbox flange, slacken the four centre-bearing clamp-screws, release the lubrication pipe and unscrew the dowel locating the housing on the cross-member. The centre-bearing housing can then be moved along the cross-member until the shaft is clear of the gearbox and the front end slung conveniently. Do not allow the shaft to hang from the centre bearing.

Removal of Propeller Shafts

Before removing the front propeller shaft, the rear shaft must be removed. In all cases this can be disconnected at the flanges and lifted clear.

To remove the front shaft, take out the four centre-bearing clamp-screws, and remove the cap, release the lubrication pipe, disconnect the front coupling at the gearbox flange, and lift out the shaft and centre bearing together.

Dismantling Centre Bearing

Remove the propeller shafts as outlined above, take off the flange retaining nut (*D*), Fig. 1, and slip the flange off the splines. The inner

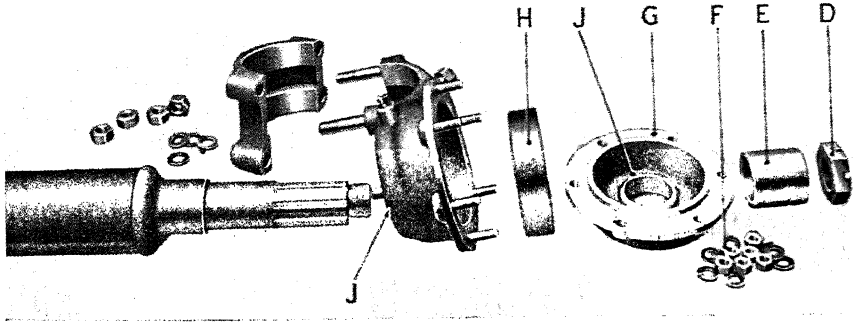


Fig. 1.—DISMANTLING CENTRE BEARING

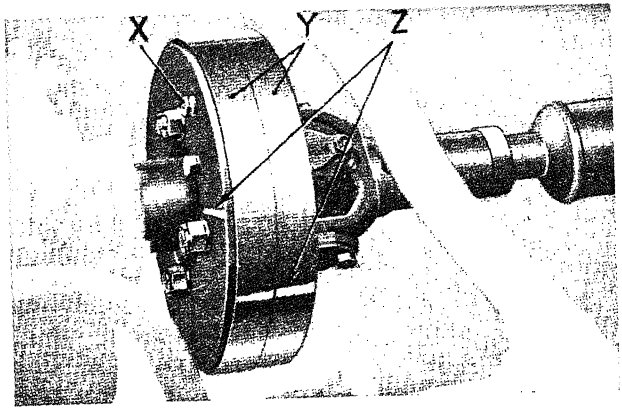


Fig. 2.—TRANSMISSION DAMPER

race is a push-fit on the shaft and is locked by pulling the flange up against a distance-sleeve (*E*).

Take off the nuts (*F*), Fig. 1, and remove the cover (*G*), the bearing (*H*) can then be knocked out of the housing, in which it is a press fit.

Oil loss is prevented by leather oil seals. These should be renewed if oil leakage is apparent.

If the bearing is to be renewed, knock the old bearing out of the housing and press in the new one.

The spherical-seating ring is not hardened, and care should be taken not to damage it in any way when pressing the bearing into the housing.

Reassembling Centre Bearing

Replace the bearing and housing on the shaft, taking care not to damage the oil seal, pack with grease and replace the cover. Slip on the distance-sleeve (*E*), fit the flange on the splines, and tighten the nut (*D*) hard, locking with the split-pin. When replacing the centre bearing on the cross-member, make sure the dowel screw is in position, and do not forget to connect up the lubrication pipe.

Couplings

All-metal needle-bearing Spicer couplings are used, or Leyrub couplings. Particulars concerning overhaul of these couplings are given in Vol. I.

Damper

On certain machines a friction-type damper is fitted in the transmission line. The damper is of simple construction and should require little attention beyond regular lubrication through the nipple (*X*), Fig. 2.

In the event of noise developing in the transmission, the damper should be checked for effective operation in the following manner.

Check that the loose rings (*Y*), Fig. 2, can be just moved by hand. If the rings are very loose the damper is not efficient, and the spring tension should be adjusted by packing the springs, or new liners should be fitted. The liners are $\frac{3}{16}$ in. thick when new. If the loose rings cannot be moved

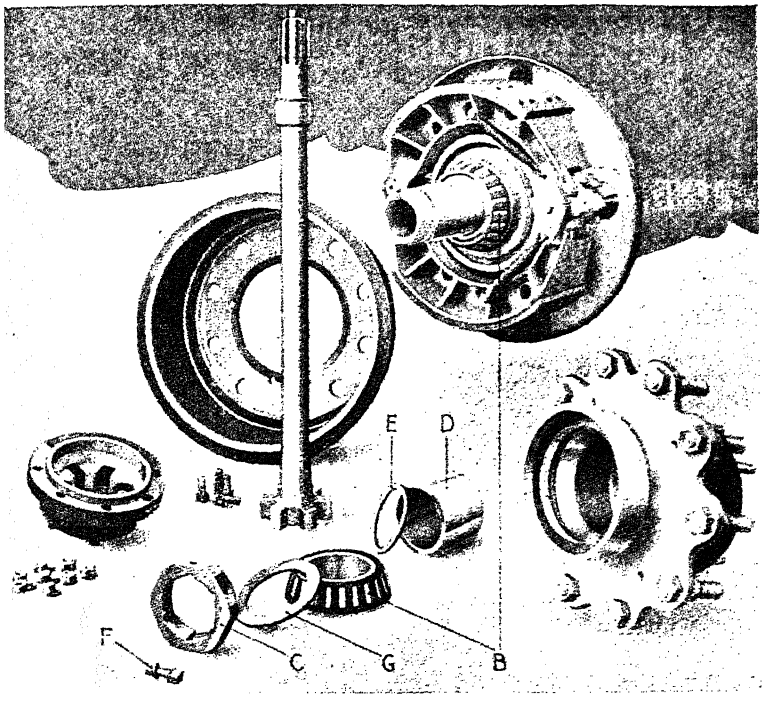


Fig. 3.—TYPICAL HUB ASSEMBLY

by hand the damper should be removed and the friction surfaces thoroughly cleaned.

A chalk mark (*Z*) should be made on the fixed plates and carried over the loose rings. If the machine is now run on the road, the relative movement of the damper plates will be shown by the position of the chalk marks. These should have separated as shown in Fig. 2. It should be noted that the period of oscillation will occur only round about one critical speed, and this speed must be gone through before the damper can be checked for correct operation. The critical speed varies from 20 to 30 miles per hour according to the type of chassis.

Removal of Damper

Disconnect the propeller shaft at the front coupling. Remove the companion-flange locking nut and draw off the flange. The damper is held together by two setscrews, and can be dismantled after removing these setscrews.

When reassembling the damper see that all the springs have been replaced, the dirt-excluding rubber ring placed in its slot, and that the spigot faces are clean and free from abrasions. *It is essential that the*

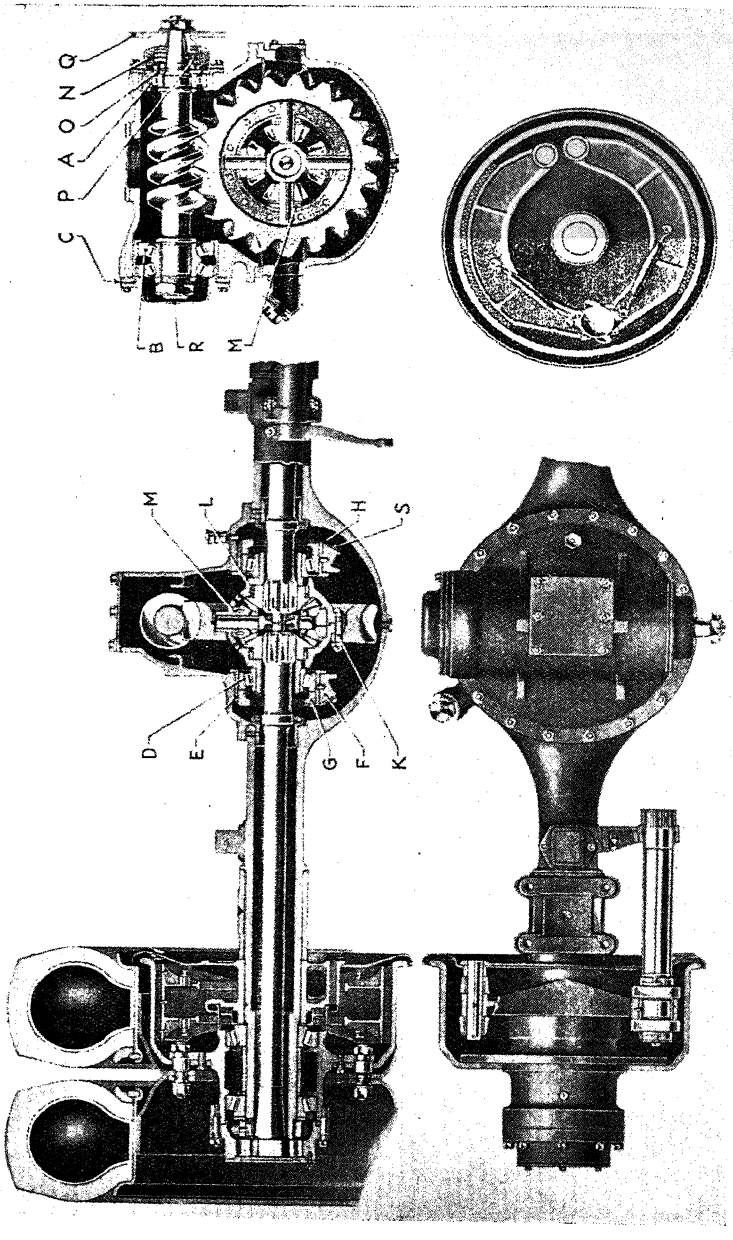


Fig. 4.—ARRANGEMENT OF OVERHEAD WORM REAR AXLE

A, worm shaft roller bearing. *B*, double taper-roller thrust bearing. *C*, shims for endwise adjustment. *D*, differential roller bearings. *E*, bearing cups. *F*, caps. *G*, adjusting nuts. *K*, alloy-steel bolts. *L*, bushes. *M*, renewable wearing pads.

damper runs perfectly true. Do not use a hammer to fit the damper on the spigot. The fixed plates are of light construction, and if these are distorted the damper will not operate effectively.

REAR AXLE

General Maintenance

The hub bearings should have end play of ·005 in., but this should not be allowed to become excessive. Check after the first 5,000 miles and adjust if play exceeds ·005 in., as outlined under "Adjustment of Hub Bearings."

Tighten the nuts round the worm carrier flange after 2,000 miles, and check periodically to prevent oil leakage. Check frequently that the spring-clip nuts are dead tight.

Withdrawal of Axle Shafts

Remove the nuts securing the hub cap, and draw off the hub cap by screwing jacking bolts into the tapped holes provided ; the axle shaft can then be withdrawn.

When replacing the hub cap make sure that the joint is in good condition and that the nuts are hammered tight ; they must not be just hand-tight.

Adjustment of Hub Bearings

The hubs are carried on taper roller bearings, mounted on the axle tubes. The bearings in each hub are secured by a large nut, a distance sleeve, and shim rings, enabling the desired adjustment to be obtained. The bearings are set by inserting suitable shim rings (available in various thicknesses), screwing up the nut and locking it with the locking bolt. The nut has six alternative positions for locking, and shim washers of various thicknesses are available to facilitate bringing the nut into the correct position for locking. It is important that the large nut be hammered tight ; on no account must it be slackened back to insert the locking bolt.

The bearings are correctly adjusted when the hub will rotate freely with approximately ·005-in. end play. Make sure that the locking bolt is split-pinned and the hub filled with grease before fitting the hub cap.

Adjustment of Worm Shaft

The worm shaft is carried in a roller bearing, the thrust being taken by a double taper roller bearing. Endwise adjustment is effected by means of shims fitted between the bearing housing flange and the cover ; shims are available in three thicknesses.

The worm shaft should have a minimum of ·007-in. end play. *This is important.* The correct clearance can be obtained by fitting the end cover with shims so that the worm shaft can only just be turned by hand.

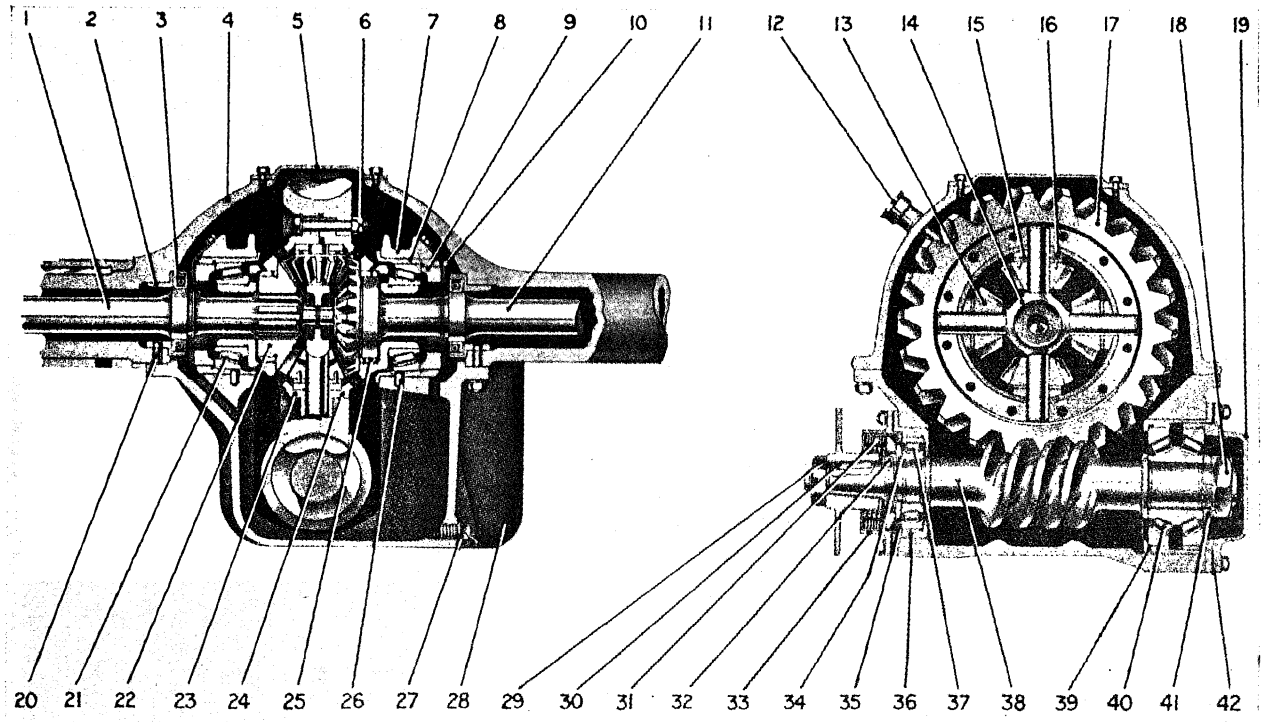


Fig. 5.—SECTION THROUGH UNDERSLUNG WORM REAR AXLE

1. Axle shaft (short).
2. Oil-seal housing.
3. Oil seal.
4. Axle casing.
5. Inspection cover.
6. Differential bolt.
7. Differential-bearing cap.
8. Differential-bearing cup.
9. Adjusting nut.
10. Locking plate.
11. Axle shaft (long).
12. Breather.
13. Differential pinion.
14. Differential spider.
15. Steel wearing plate.
16. Bronze wearing plate.
17. Worm wheel.
18. Rear-bearing nut.
19. Rear cover.
20. Oil-seal dowel screw.
21. Differential bearing.
22. Differential side pinion.
23. Serrated half diff. casing.
24. Spigot half diff. casing.
25. Side-pinion bush.
26. Bearing cup dowel.
27. Drain plug.
28. Worm carrier.
29. Coupling-flange nut.
30. Coupling-flange key.
31. Packless gland.
32. Worm-shaft nut (front).
33. Gland housing.
34. Gland-seating washer.
35. Shims.
36. Front-bearing housing.
37. Worm-shaft bearing.
38. Worm shaft.
39. Rear-bearing housing.
40. Rear bearing.
41. Rear-bearing washer.
42. Shims.

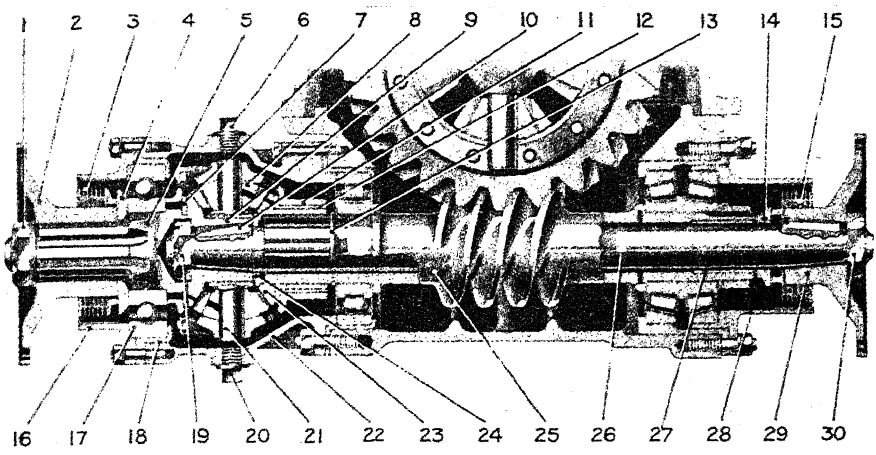


Fig. 6.—SECTION THROUGH THIRD DIFFERENTIAL

1. [illegible] nut (front).
2. [illegible].
3. [illegible].
4. [illegible].
5. [illegible] case.
6. [illegible].
7. Wearing washer.
8. Differential pinion.
9. Differential side pinion (front).
10. Key for side pinion.
11. Rear half differential casing.
12. Flanged bush.
13. Circlip.
14. Gland seating (rear).
15. Packless gland (rear).
16. Gland housing (front).
17. Ball bearing.
18. Bearing housing (front).
19. Nut for differential pinion.
20. Drain plug.
21. Differential spider.
22. Third differential casing.
23. Differential side pinion (rear).
24. Wearing washer.
25. Worm shaft.
26. Solid shaft.
27. Bush for solid shaft.
28. Gland housing (rear).
29. Coupling flange (rear).
30. Coupling-flange nut (rear).

The addition of one shim ·010 in. thick between the housing and cover will then give the desired running clearance. The adjustment should be carried out with all bearings in a clean and dry condition.

Adjustment of Differential Side Bearings

The differential roller bearings are carried in bearing cups which are split to nip the bearings when the caps are pulled down. The bearing cups are dowelled into the housing to prevent rotation when the adjusting nuts are tightened up. The adjusting nuts are locked by the locking plates fastened to the caps by setscrews.

The side bearings should be adjusted so that there is ·008-in. end play. Undue clearance results in a noisy axle and excessive wear of the worm wheel.

Ordinary running adjustment should be made on the left-hand (or nearside) bearing, which does not alter the alignment of worm and wheel. Do not disturb the right-hand bearing except when dismantling for overhaul or renewal.

Removal of Worm Wheel (Overhead type)

Remove bearing caps and lift the differential assembly clear of its bearings. The roller races and adjusting nuts will then draw clear.

The worm wheel is bolted to the differential casing by alloy-steel bolts fitted in reamed holes ; the bolts project through the nuts and are wired together, as are the bolt heads.

To remove the wheel, press from the differential casing and the differential gears can be removed. The wheel has teeth formed on the recess which engage with corresponding teeth on the differential casing. There is a slight interference as the wheel is pressed on, which ensures a metal contact and a good fit. The wheel is aligned on the differential casing by a spigot.

The bushes on the side differential pinions are fully floating and are made a very slack fit to avoid seizure. Three $\frac{5}{16}$-in. holes are drilled through the differential side cases to facilitate removal of the roller races. Renewable wearing pads are fitted behind the differential pinions.

Reassembling Differential

When assembling, see that all index marks coincide and that the contact faces are perfectly clean. The worm wheel must be pressed on the casing and the bolts split-pinned and wired together.

It is important that the worm wheel and differential assembly be fitted in the worm carrier the correct way round.

The heads of the differential bolts should be in the position so as to relieve the nuts of any direct loading.

Removal of Worm Shaft (Overhead type)

Draw off the coupling flange and remove the cover ; tapped holes are provided for jacking bolts. Draw the shaft through with the thrust bearing housing by screwing jacking bolts into the tapped holes provided in the housing flange ; the journal-bearing housing will be left in position. It should be noted on six-wheeled machines that the thrust race is at the front end of the worm shaft on the centre axle and at the rear end on the rearmost axle.

Removal of Worm Wheel (Underslung Worm Axle)

Remove bearing caps and lift differential assembly clear with its bearings. The outer races, cups, and adjusting nuts can then be removed.

To remove the worm wheel take out all the bolts, and if no press is available drive out the serrated half of the differential casing, using a brass drift about 2-in. diameter through the other half-case. The second half-case can then be driven out. If the case is tight, immerse the assembly in boiling water for fifteen minutes and then drive out the half-cases.

Alternatively, the worm wheel can be sawn through and the half-cases driven out. If this is done the bearings should be protected from swarf if they are to be used again.

Three $\frac{5}{16}$-in. holes are drilled through the half-cases to facilitate knocking off the bearings when renewing.

Fig. 7.—ANOTHER ARRANGEMENT OF OVERHEAD WORM REAR AXLE

A, shims for end-wise adjustment. *B* and *C*, bearings. *D*, bearing cups. *E*, cups. *F*, adjusting nuts. *G*, set-screws.

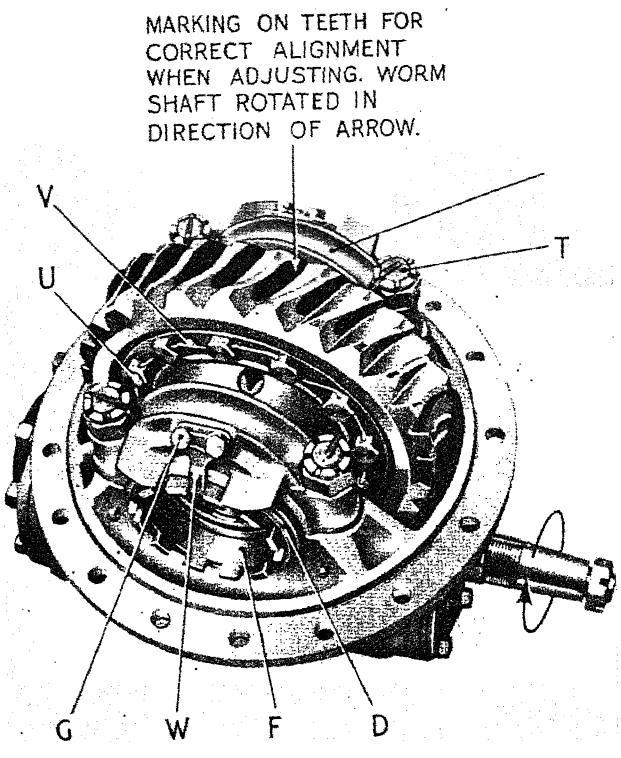


Fig. 8.—ALIGNMENT OF WORM AND WHEEL (OVERHEAD TYPE)
T, nuts. *E*, caps. *D*, cups. *F*, adjusting nuts. *W*, locking plates.

Replacing Worm Wheel (Underslung Worm Axle)

Renew the wearing pads (16), Fig. 5, behind the differential pinions if worn, and also the side-pinion bushes; the bushes are an easy fit on the pinions. If new roller bearings are to be fitted, replace the worm wheel on the casing before fitting the new bearings.

Immerse the worm wheel, flanged side down in boiling water, supporting it so that a hook can be slipped underneath to lift it out. Keep the water at boiling point for fifteen minutes.

Bolt the differential-case assembly solid by means of a long bolt through the centre and two pieces of flat steel or large washers. Clean any burrs off the fitting surface with a smooth file and remove any dirt with a wire brush. Smear the serrations liberally with oil.

If boiling water has been used to remove the worm wheel, allow the differential cases to cool off fully before fitting the new wheel.

Lift the worm wheel from the boiling water by means of a hook and support it on three wood blocks high enough to allow the differential assembly to go right home. Wipe the inside of the wheel clean and quickly insert the assembly, *taking care that the bolt holes correspond.* The wheel and casing are worked to facilitate registering the holes. Push the assembly down as far as possible and drive home, using a brass drift round the periphery, taking care to drive in evenly all round and that the assembly goes right home on the spigot.

Replace and tighten the bolts, remove the temporary fixing, wire the bolt ends and heads together.

If the roller bearings have not been removed, wash carefully with paraffin to remove all dirt and filings. If new ones are to be fitted, press or drive them on to the casing.

Removal of Third Differential (Six-wheelers)

On six-wheelers the third differential must be removed before the worm shaft of the centre axle can be withdrawn. This unit is housed in a casing secured to the front of the worm carrier. The worm shaft (25), Fig. 6, is hollow and the drive is transmitted to the third axle by a shaft (26) which passes through the hollow worm shaft. Renew the ring (7) and flanged bush (12) if the pinions are slack. The bush is an easy fit on the casing.

Removal of Worm Shaft (Underslung Worm Axle)

Draw off the front coupling flange, remove the gland housing (33), Fig. 5, remove the third differential on centre axles of six-wheelers. Take off the rear cover (19), screw jacking bolts into the tapped holes in the bearing housing (39), and draw out the worm shaft with the rear bearings. Two slots are provided in the shoulder on the worm shaft to enable the rear bearing to be driven off with a small bar.

Worm-shaft Gland

Oil loss along the worm shaft is prevented by means of a packless gland fitted on the front end of the worm shaft. On six-wheeled machines similar glands are fitted at both ends of the worm shaft on the centre axle.

The gland consists of a thin copper bellows, soldered to the cover, and having a bronze seating ring at the inner end. The necessary pressure against the seating washer is supplied by the spring. The gland requires no adjustment ; if after a long period of service oil leakage is apparent, a complete new gland should be fitted and the old one returned to Leyland Service Department for reconditioning.

Alignment of Worm and Wheel (after Overhaul or Renewal)

When reassembling after overhaul a double adjustment is necessary for alignment of worm and wheel and adjustment of differential side-bearings.

Clean all trace of oil from the worm carrier, fit the worm shaft, and adjust for end play. Coat the worm with a thin layer of marking blue and place the differential in position ; tighten the nuts so that the caps barely nip the cups on the outer races. Take all end play out of the side bearings by screwing up the adjusting nuts on both sides ; then adjust the right- and left-hand nuts, thus moving the worm wheel sideways until the correct alignment is obtained.

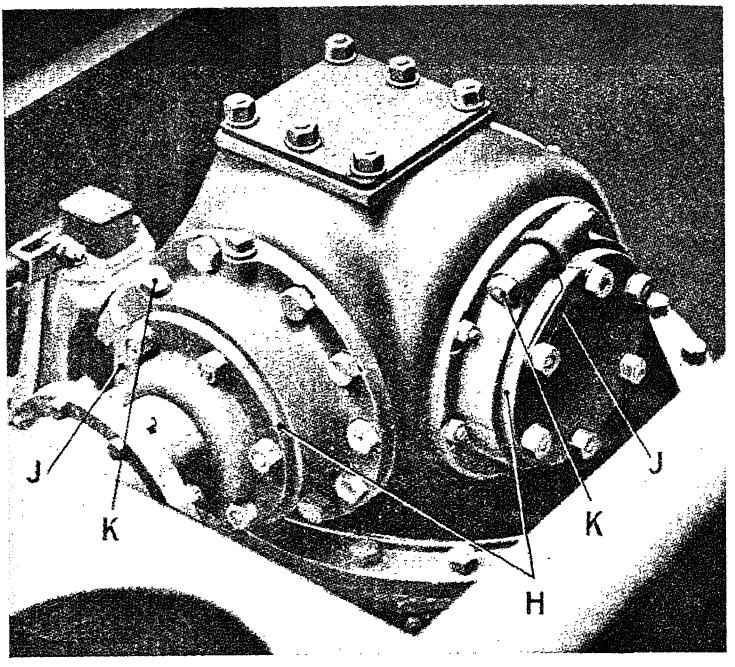


Fig. 9.—ADJUSTMENT OF BEVELS, DOUBLE-REDUCTION TYPE AXLES

Having obtained a tight adjustment by screwing up both nuts, slacken off each nut one notch and rotate the worm shaft in the direction of the arrow in Fig. 8, keeping a load on the worm wheel so as to obtain a good marking.

Fig. 8 shows the appearance of the wheel when in correct alignment. When rotating the worm shaft, the driving face of the tooth should show a marking of from one-half to three-quarters the width of the tooth on the leaving side. The entering side should not show marking ; when under load the contact will pull into centre.

If the wheel is loaded in a direction corresponding to " coasting," the contact marking will show on the opposite face of the tooth on the opposite hand.

When the alignment is correct, check for end adjustment, tighten and pin the nuts, and fix the locking plates (*W*). The setscrews should be wired together.

Replacing Worm Carrier

Before lowering the worm gear into the axle casing check that the leather oil seals on the axle shafts are in good condition. These are

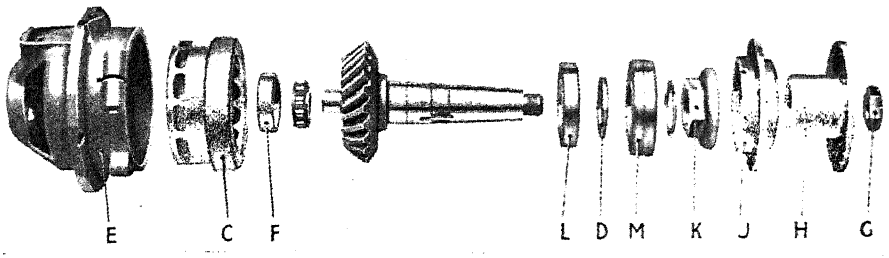


Fig. 10.—REMOVAL OF BEVEL-PINION SHAFT

mounted in aluminium sleeves located in the axle casing by dowel screws. The sleeves are a light tapping fit and can be withdrawn after removing the dowel screws.

When replacing the worm carrier see that the paper joint on the flange is not broken and check that the coupling flange is well home on the taper end of the worm shaft. See that the hub caps are tightened up.

Double-reduction-type Axles

Another rear axle is the fully floating double-reduction type, the first and second reductions being through spiral bevel gears and a double helical gear set respectively. Both bevel pinion and gear are adjustable for correct mesh, the double helical gear having sufficient end float to adjust itself to the pinion.

All pinions and gears are mounted in roller bearings, and large thrust-races are provided on the pinion shafts. The wheel hubs are mounted on taper roller bearings and need not be disturbed when removing brake drums and shoes.

Adjustment of Bevel Pinion and Gear

The double adjustment provided by the two adjusting rings (*H*), Fig. 9, permits of accurate meshing of the bevels to obtain quiet running. The bevel gear is moved laterally in the housing, and the pinion fore and aft, as the adjusting rings are screwed in or out.

Some backlash must be allowed, approximately ·005 in., otherwise the axle will be noisy under load and tooth wear will be rapid. If too much backlash is allowed the axle will probably be noisy on the overrun.

To adjust the bevels, remove the locking plates (*J*), Fig. 9, slack off the clamp-bolts (*K*), and turn the adjusting rings by inserting a small tommy-bar between the nuts securing the cover plates. Turn right for deeper mesh on the pinion shaft, left for deeper mesh in the case of the bevel gear. The bevels should be adjusted to have approximately ·005-in. backlash, and the vehicle then tried on the road for quiet running, until the most satisfactory adjustment is found.

When the adjustment is completed replace the locking plates and tighten the clamp-bolts.

Removal of Double-reduction Gear

Draw the axle shafts as already outlined and disconnect the Spicer coupling at the flange. Take off nuts from studs, and on six-wheelers disconnect the radius rod from the axle. The reduction gear can now be lifted out of the axle casing by means of a sling.

Removal of Differential Assembly

The double helical gear is spigoted on the differential casing and secured by alloy-steel bolts fitted in reamed holes ; the assembly is carried on roller bearings secured by caps (*A*), Fig. 11.

To remove the assembly unscrew the four nuts and remove the caps (*A*), when the assembly can be lifted clear. Remove the bolts, and the gear can be drawn off the spigot on the differential casing. The two halves of the differential casing can then be taken apart and the pinions inspected.

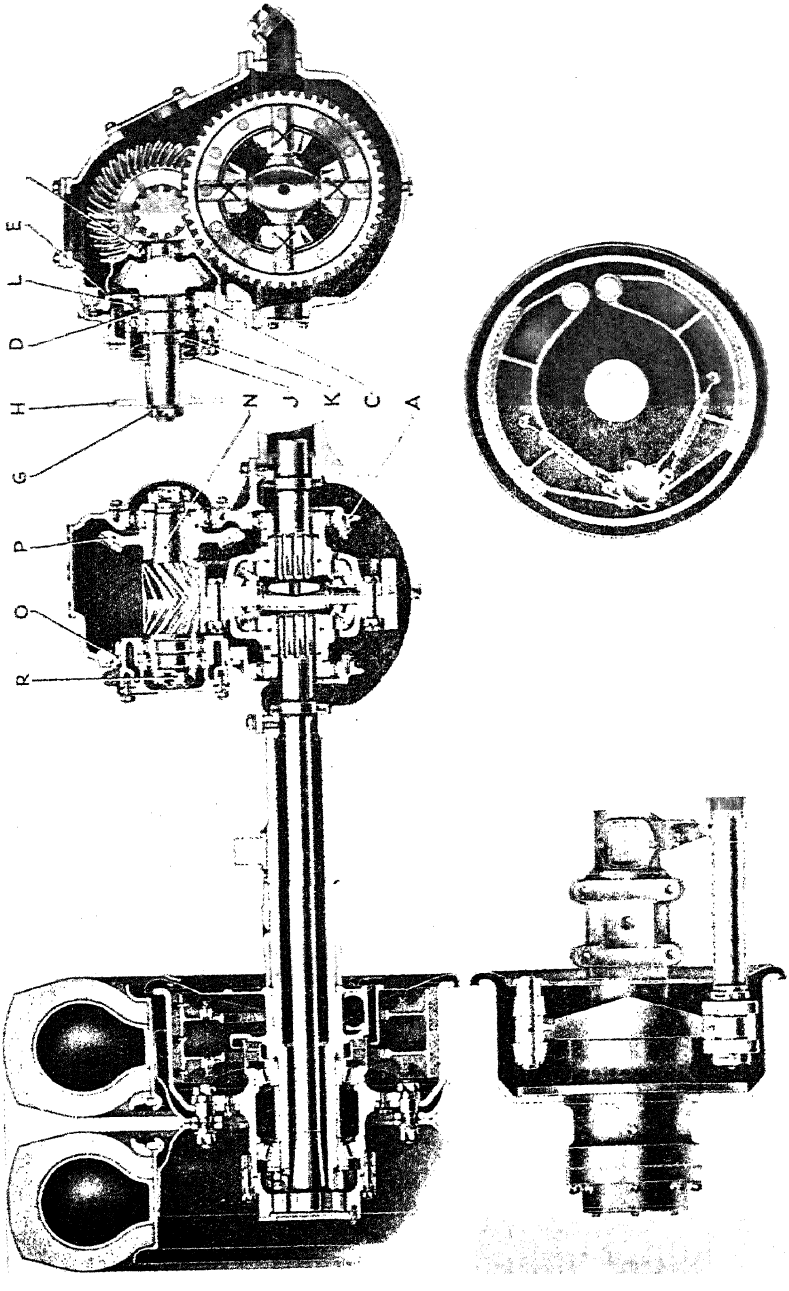
When reassembling see that the index marks on the differential side-cases coincide and that the contact faces are free from foreign matter which could prevent a perfect joint. The double helical gear should also be quite clean to ensure a good contact when pulled up on the spigot. The nuts must be tightened solid and split-pinned ; do not slack off a nut to insert a split-pin.

Removal of Bevel-pinion Shaft

The bevel-pinion shaft is carried in a roller bearing and a large thrust-race housed in an adjusting ring (*C*), Figs. 10 and 11. The bearings are locked on the shaft by a nut and tab washer, an oil flinger being secured to the nut by dowel screws. The adjusting ring is designed to ensure an adequate supply of oil to the bearings, a distance-washer (*D*) being fitted between the inner races of the bearings further to allow of efficient lubrication. The roller bearing is of the single-lipped type, and care must be taken when reassembling to ensure that the lipped side of the race is at the bottom.

The adjusting ring screws into the bevel-shaft housing (*E*), the shaft being supported beyond the pinion in a roller bearing, the outer race of which is a press-fit in the housing. The adjusting ring is secured by a clamp-bolt in a split-lug on the housing. A locking plate is provided, and a felt pad in the slot prevents oil leakage. The Spicer coupling companion flange is keyed on the taper end of the shaft.

To remove the shaft, unscrew the setscrews securing the shaft housing to the main housing and the assembly can be drawn out. Slack off the clamp-bolt, remove the locking plate and unscrew the adjusting ring (*C*), Fig. 10, the shaft will be drawn clear of the housing, leaving the outer race of bearing (*F*) in the housing. Remove the nut (*G*) and draw off the


E
L
D
H
G
P
O
R
N
J
K
C
A

Spicer flange (*H*), take off the cover plate (*J*) and unscrew the nut (*K*). Support the adjusting ring on the bench and give a sharp tap on the end of the shaft with a lead hammer, and the shaft can be drawn through the bearings.

When reassembling, fit the outer race of the roller bearing (*L*) in the adjusting ring with the lip downwards, and place the adjusting ring over the shaft. Fit the inner part of the roller bearing (*L*) on the shaft, then the distance-washer (*D*) and thrust-race; tighten the locking nut solid and lock with the tab washer. It is essential that the split outer race of the thrust bearing (*M*) be seated correctly before tightening down the cover plate. The Spicer flange must be a perfect fit on the taper, and the nut hammered tight.

Removal of Double-helical-pinion Shaft

The double-helical-pinion shaft (*N*), Fig. 11, is carried in a roller bearing and thrust-race housed in an adjusting ring. No distance-washer between the bearings is fitted in this case, and the roller bearing is not lipped. The adjusting ring screws into a special housing (*O*) bolted to the gear housing, and is secured by a locking plate and clamp-bolt. The bevel gear (*P*) is keyed on the taper end of the shaft and on it is mounted a roller bearing. Both bearing and gear are secured by a nut and split-pinned, the outer race being locked by the cover plate. To remove the shaft take off the cover from the adjusting ring, wedge the gear with a small bar of soft metal, and take off the locking nut (*R*). Slack off the clamp-bolt and place a small bar between the gear and housing so that when the adjusting ring is screwed out it will draw the thrust-race off the shaft. The shaft can then be withdrawn through the rear end of the gear housing.

The gear can be released from the taper by unscrewing the locking nut, supporting the gear on two blocks of wood, and giving a sharp blow on the end of the shaft with a lead hammer, or using a suitable drawer.

When replacing see that the gear is a perfect fit on the taper and that the nut is hammered tight and split-pinned.

Reassembling Reduction Gear

Fit the double-helical-pinion shaft in the offside roller bearing, and place the adjusting ring and housing in position. Tap the bearings on the shaft and tighten the locking nut solid.

It is essential that the split outer race of the thrust bearing be properly bedded before tightening down the cover plate.

Next fit the bevel-pinion assembly and finally the differential assembly. The bevels should be adjusted by means of the adjusting rings until there is approximately ·005-in. backlash. The mesh of the bevel pinion and gear can be checked by smearing the teeth of the pinion with marking blue and turning the pinion shaft in the normal running direction.

The marking should show about the middle of the gear teeth and along the whole of the width. The clamp-bolts should be tightened when the correct adjustment is obtained.

Before replacing the reduction gear in the axle casing check that the leather oil seals on the axle shafts are in good condition. These are mounted in aluminium sleeves located in the axle casing by dowel screws under the housing flange. The sleeves are a light tapping fit and can be withdrawn after removing the dowel screws.

Tab Washers, Split-Pins, and Chip Guards

It is important that the nuts indicated as being locked by tab washers or split-pins should have these safeguards fitted when reassembling; should the tabs break off on removal, new washers should be obtained and split-pins should be a good fit in the holes.

It is also essential that all chip guards should be replaced in their correct positions behind the bearings.

Ensure that all joints are in good condition to prevent oil leakage, and tighten the nuts round the housing flange after 2,000 miles' running.

Running Adjustment of Bevel Pinion and Gear

The most satisfactory method of obtaining the quietest adjustment of the bevel gear after overhaul or renewal is by running the vehicle on the road. Slack off the clamp-bolts and turn the adjusting rings until the quiet-running position is found; very little movement of the rings should be necessary. Fit the locking plates and felt pads and tighten the clamp-bolts hard when adjustment is completed.

Removal of Axle

The chassis should be well packed up both behind and in front of the axle to avoid excessive overhang.

On four-wheel machines disconnect the propeller shaft at the rear Spicer flange and sling the shaft to the cross-member. Disconnect the brake-operating rods, jack up the axle, and remove the road wheels.

Remove the shackle bolts and the axle can be lowered to the ground and removed.

On six-wheel machines first disconnect the propeller shaft and release the brake rods and radius rod from the axle. Jack up the axle and remove the road wheels. Next, lower the jacks slowly, whilst steadying the axle with a rope or sling, and allow the axle to turn over on the shackle pins until the top part rests safely on the ground. Finally, jack up a little to ease the shackle pins; withdraw these pins and lower the axle for removal.

Do not skid the axle on the brake dust covers; these should be kept clear of the ground.

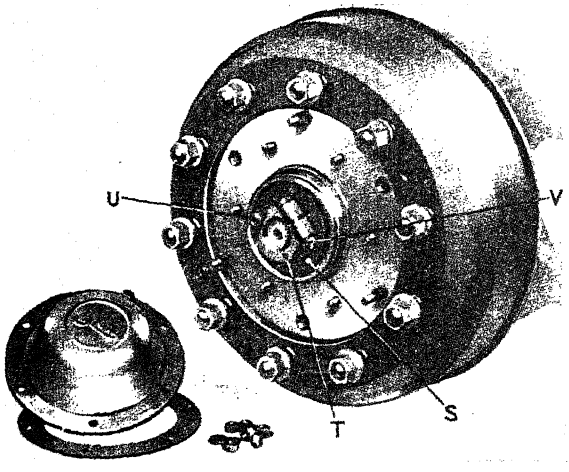


Fig. 12.—ADJUSTMENT OF HUB BEARINGS (BEAVER, OCTOPUS, AND TITAN)

BEAVER, OCTOPUS, AND TITAN FRONT AXLES

All Leyland front-axle beams are high-carbon nickel-steel heat-treated forgings. The axle arms are of nickel steel.

Adjustment of Hubs

The hubs are carried on roller bearings (*H*), Figs. 13 and 15, and these should be kept so adjusted that they have the minimum of rock or end play compatible with free rotation of the hubs.

To adjust the bearings remove the hub cap as shown in Fig. 12. The locking plate (*S*) is prevented from rotating by a flat which locates on a companion flat on the stub axle. The split-nut (*T*) has a lug into which is screwed a locking peg (*U*), the end of which fits in the appropriate one of a number of holes provided in the locking plate (*S*). The split-nut is clamped by a bolt (*V*).

Slack off the clamp-bolt (*V*) and remove the peg (*U*), screw up the nut (*T*) until there is no rock in the bearings. Then slacken back the nut one hole and replace the peg (*U*). Tighten the clamp-bolt, taking care that the nut is split-pinned before replacing the hub cap.

Removal of Hubs

Take off the hub cap, unscrew the peg (*U*), slack off the clamp-bolt (*V*), and screw off the nut (*T*). The hub can now be drawn off, bringing with it the outer roller bearing. When replacing, the hub must be packed with grease and carefully adjusted as already outlined.

Removal of King-pin

The king-pin (*J*), Figs. 13 and 15, fits in a taper in the axle beam, and is secured by a nut (*K*) pulled up on a distance-collar (*L*) and locked by a tab washer. Loss of lubricant is prevented by a felt washer (*M*) in a metal casing at the top and the cover plate (*N*) at the lower end.

To remove the king-pin in the case of Beaver and Octopus chassis (Fig. 13), take off the four nuts securing the servo to the platform, swing the servo carefully out of the way (take care not to strain the brake-operating linkage), and take off the cover plate (*N*). Slack off the nut

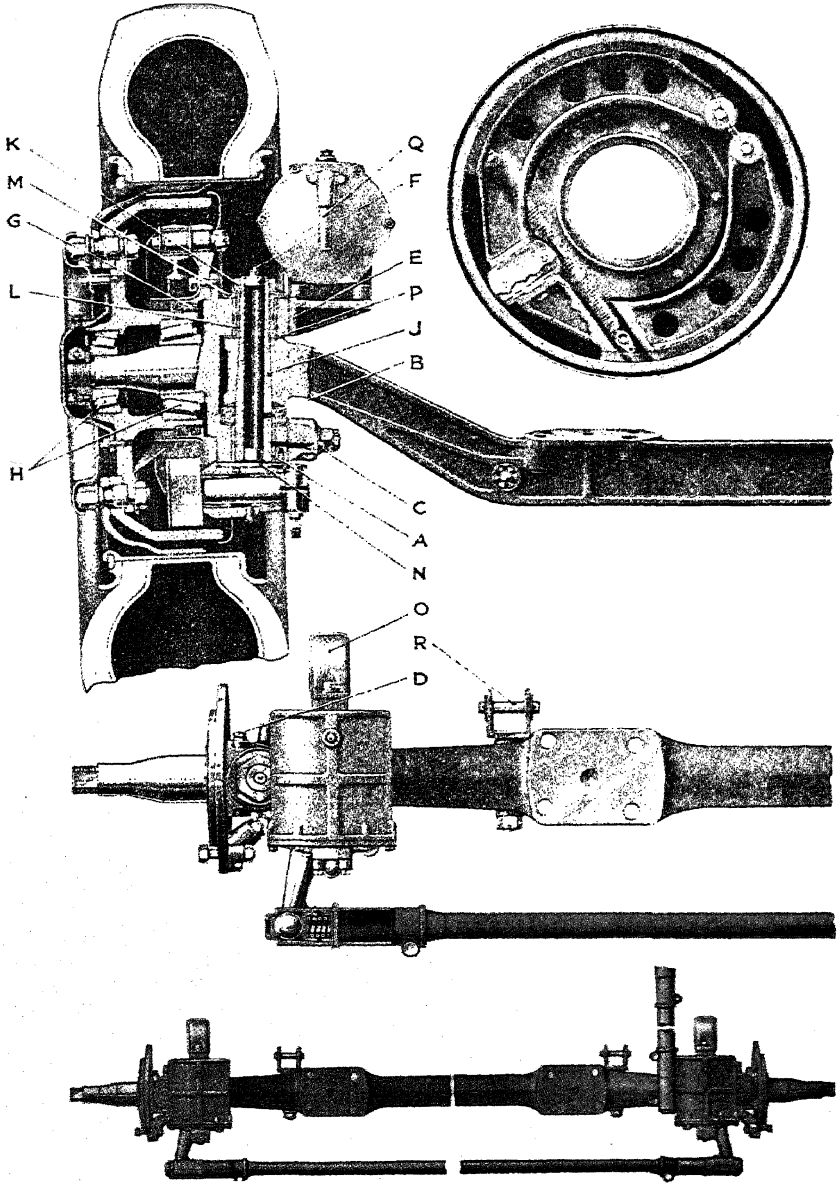


Fig. 13.—ARRANGEMENT OF FRONT AXLE (BEAVER AND OCTOPUS)

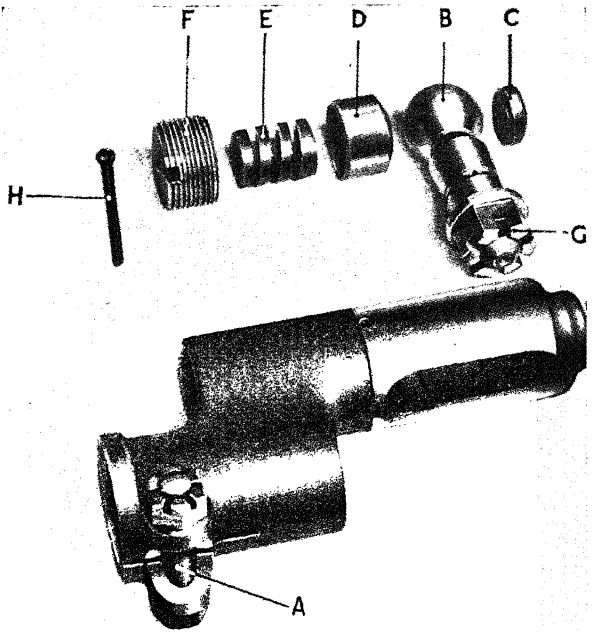


Fig. 14.—TRACK-ROD END

(*K*) one or two turns and release the king-pin, using a heavy lead hammer or a lead drift. Once the pin is released from the taper the nut can be removed and the pin will slip through.

To remove the king-pin on the Titan front axle, disconnect the brake-fluid pipe at the union (*O*) and remove the expander. Slack off the clamp-bolt (*P*) and remove the brake-camshaft lever, first marking the relative positions so that the lever can be replaced on the correct spline. Remove the nut (*Q*) and take off the cover; remove the lower cover plate (*N*). Slack off the nut (*K*) one or two turns and release the king-pin by striking the top end, using a heavy lead hammer or a lead drift. Once the pin is released from the taper the nut can be removed and the pin will slip through.

When replacing the king-pin on the Beaver, Octopus, and Titan chassis, see that the spherical seat for the thrust race is in position, and check that there is no undue clearance between the axle arm and the axle beam. The axle arm should be free, *without any up and down play*, and shim washers are available in six thicknesses for taking up such play. The washer used should be of such thickness that it is a push-fit between the axle arm and axle beam at (*P*) (Fig. 13) or (*R*) (Fig. 15). Before fitting the thrust-race it should be thoroughly washed in paraffin, dried, and packed with grease and enclosed in the mudproof casing. Never use a thrust-race that shows signs of wear or pitting. Tighten up the nut (*K*) hard, and lock with the tab washer.

Steering and Track-rod Connections

The steering and track-rod ends are one-piece forgings screwed to the rods for adjustment and clamped by a nickel-steel bolt (*A*), Fig. 14. The clamp-bolt should be inspected frequently for tightness; if a replacement is necessary, an ordinary mild-steel bolt must not be used.

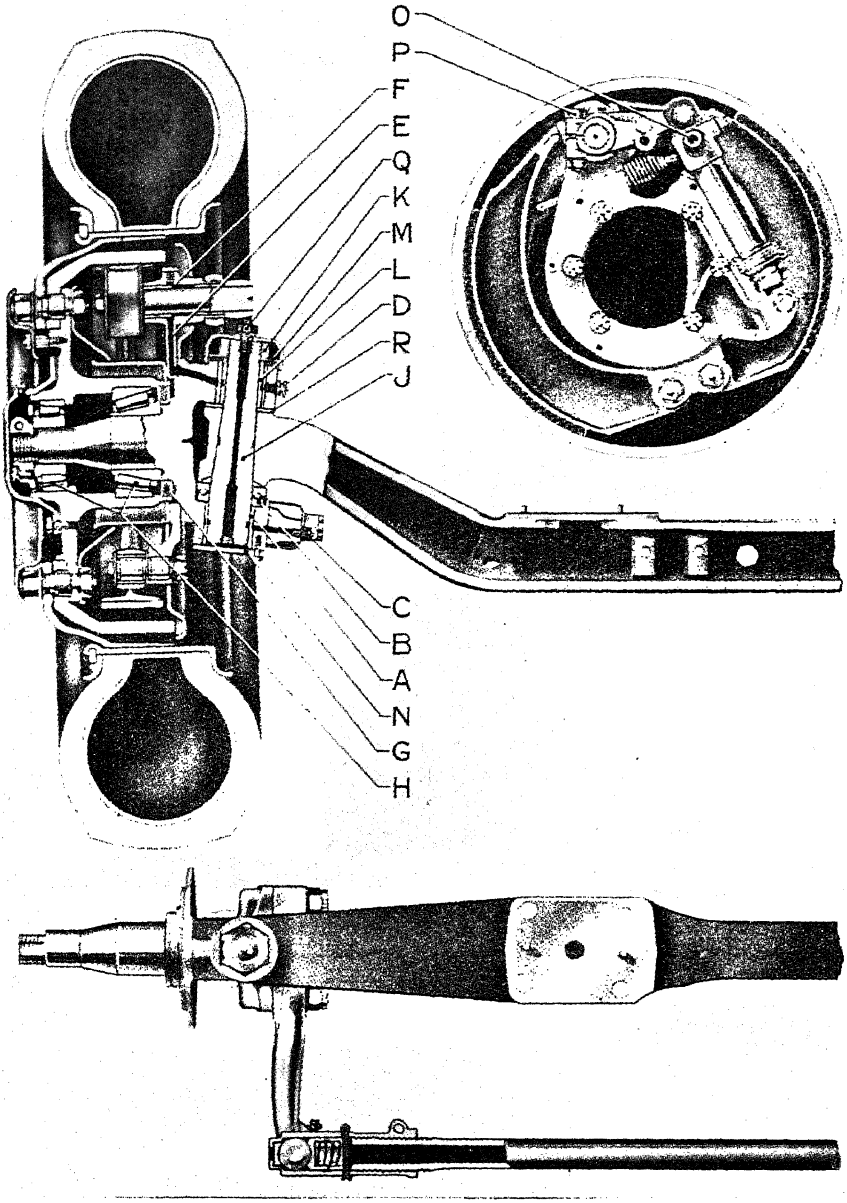


Fig. 15.—ARRANGEMENT OF FRONT AXLE (TITAN)

Serious damage to the adjusting thread will result if the bolts are allowed to remain loose.

The ball (*B*) is carried between cups (*C*) and (*D*), and a heavy, square-section coil spring (*E*) is inserted between the cup (*D*) and the spring housing (*F*). The rod cannot come adrift in the event of the spring breaking, as the slot in the steering-rod end is less than the diameter of the ball.

Removal of Ball End

Take off the nut (*G*) and release the ball-pin from the taper in the steering arm ; slack off the clamp-bolt (*A*) and unscrew the steering-rod end. Take out the cotter pin (*H*), unscrew the spring housing (*F*), and withdraw the spring and ball cup (*D*). The ball-pin (*B*) can now be removed through the end of the socket.

When replacing, clean and grease thoroughly and observe that the oil hole in the ball-pin is clear. Screw up the spring housing solid and then slack back half a turn, to ensure that the ball is not nipped. Be sure that the clamp-bolt (*A*) is well tightened and the nut split-pinned.

Track and Track Adjustment

The front wheels should be tracked up dead parallel. The ends of the track rod are screwed right- and left-hand threads to facilitate this adjustment.

Removal of Front Axle

Pack up under the frame side-members and disconnect the drag-link from the steering arm. In the case of Beaver and Octopus chassis, release the brake suction pipes at the hose clips at (*Q*), Figs. 13 and 15, and withdraw the shock-absorber connecting pins (*R*) when fitted. With Titan chassis, release the brake-fluid pipes at the unions. Remove the road-spring clips in all three types of chassis and the axle can be drawn clear. Do not drag the axle along the ground on the brake dust covers.

When replacing, ensure that the road-spring clips are dead tight; these should be tightened with a long spanner and split-pinned.

LINX FRONT AXLE

Adjustment of Hub Bearings

On the Linx chassis the hubs are carried on taper roller bearings (*E*) Fig. 15, and these should be kept adjusted so that there is not more than ·005-in. end play.

To adjust the bearings remove the hub caps. The adjusting nut has six slots and the stub axle two holes at right angles, so that there are twelve positions for locking the hut with the split-pin. When reassembling or adjusting, screw up the nut until the bearings are just tight, then

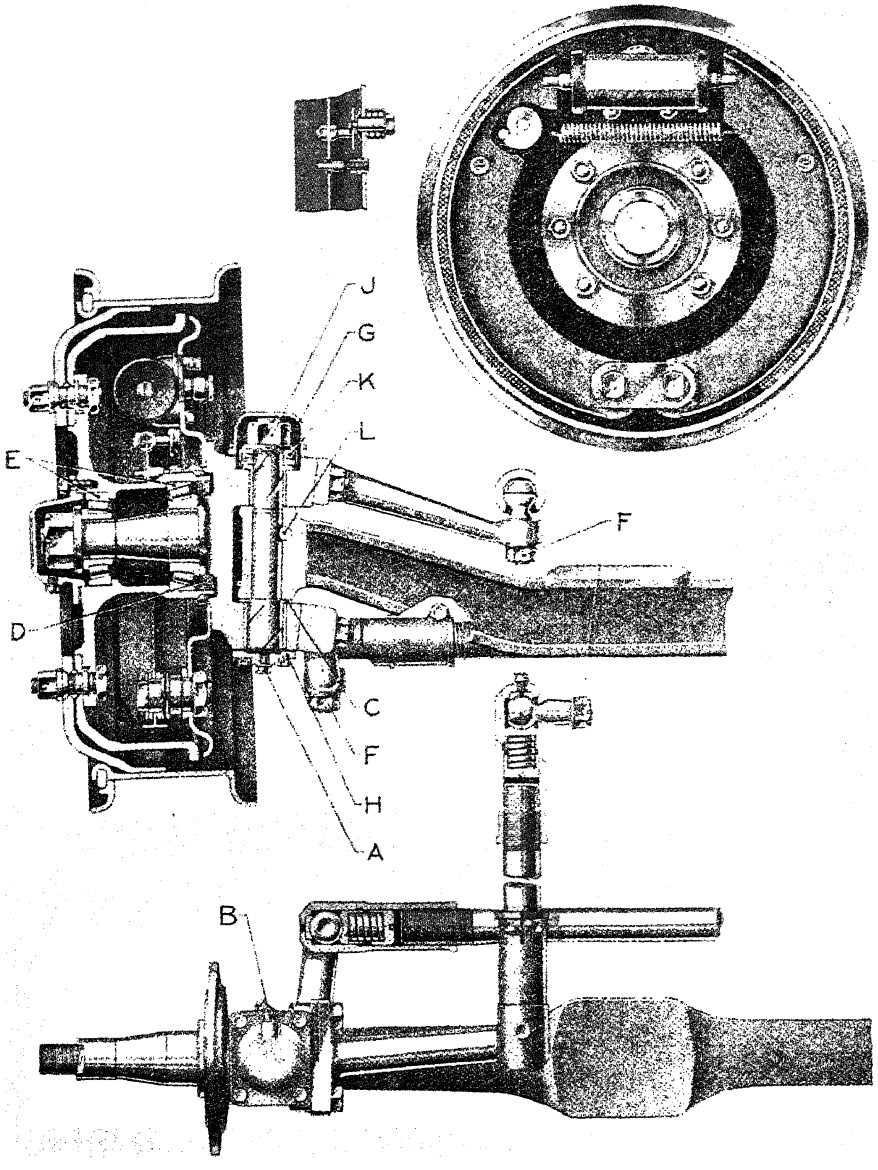


Fig. 16.—ARRANGEMENT OF FRONT AXLE (LINX)

slack back the nut till the nearest slot and hole are in line to insert the split-pin.

Removal of Hubs

To remove the hub take off the hub cap and unscrew the nut. The hub can then be drawn off, bringing with it the outer roller bearing.

If the bearings are to be renewed the outer races can be knocked out of the hub. Before pressing home the new races check that the recesses are free from foreign matter, which might prevent them going right home. Pack the hub with grease and adjust for end play as already outlined.

Removal of Axle Arm

Disconnect the steering connections by slacking off the nuts (*F*), Fig. 16, a few turns and drawing the pins through the steering arms. A drawer is available for this purpose ; a hammer should not be used, as there is danger of distorting the steering arms. Uncouple the flexible brake pipes ; the back plates and brake shoes need not be removed.

Take off the top and bottom covers (*G*) and (*H*), and unscrew the king-pin nut (*J*) ; the thrust-race (*K*) can then be removed. Remove the nut and drive the cotter (*L*) out towards the front, then drive out the king-pin by striking the top with a lead hammer to avoid damaging the threads.

If the bushes are worn, replace with new ones, a new king-pin being fitted if the new bushes are too slack on the old pins.

To reassemble, drive the king-pin in from below, care being taken to ensure that the slot for the cotter is in the correct position and that the felt washer (*C*) is replaced ; the cotter must be inserted from the front.

Fit the thrust-race, if in good condition, replace if at all pitted, and screw on the nut (*J*). This nut must on no account be tightened too hard—screw down tight and then slacken until the axle arm can just be rotated. Replace the covers and lubricate the bushes.

Similar remarks apply to steering arm and track-rod connections of the Linx as already given for the Beaver chassis.

BEAVER AND OCTOPUS BRAKES

Adjusting Hand-brake

On all four-wheelers the hand-brake is adjusted by means of a wing-nut ; on six- and eight-wheelers a turnbuckle is provided on the rear operating rod. Locking nuts are provided in all cases, and these should be tightened when adjustment is completed. The hand-brake should be adjusted whenever the foot-brake is taken up. Screw up the adjusting nut until tight, then slack back half a turn to ensure that the foot-brake can be fully released.

Adjusting Foot-brake

The foot-brake adjustment on four-wheelers is by means of the adjusting nut on the cross-shaft behind the servo. Screwing up the adjusting nut brings the servo reaction lever back against its stop, thus allowing full travel for the piston. With single-servo brakes the adjustment affects all four wheels; on other machines the rear wheels only are affected.

On six- and eight-wheelers two adjusting nuts are provided behind the servos on the cross-shaft. This adjustment is for the four rear wheels only.

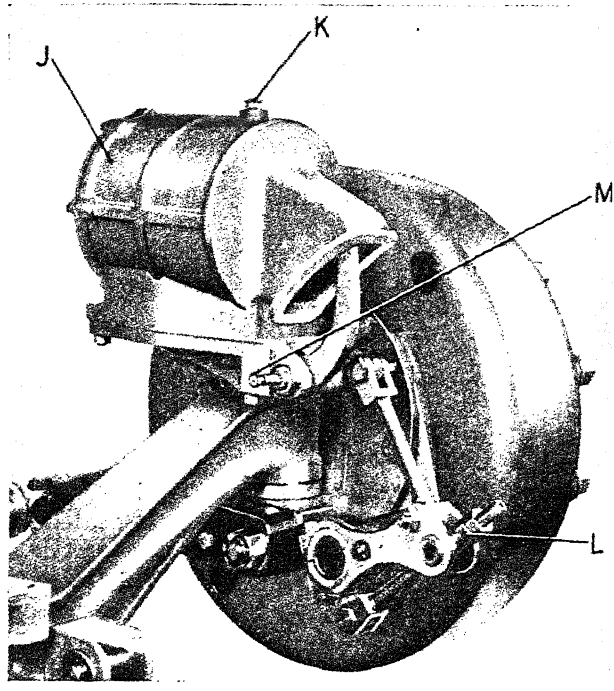


Fig. 17.—FRONT BRAKE ADJUSTMENT (BEAVER AND OCTOPUS)

Front Brakes

On all machines fitted with independent servos on the front axle, each front wheel must be adjusted separately. Jack up the axle, slack off the nuts locking the adjusting nuts (*L*), Fig. 17, and screw up the adjusting nuts until the shoes are just touching the drums, then release one half-turn and tighten the lock-nuts.

It should be noted that on all machines fitted with front-wheel servos, there is no mechanical connection between front and rear brakes. The front brakes should always be adjusted at the same time as the rear brakes.

In all cases it is most satisfactory to jack up when adjusting brakes, so that it is possible to test, by rotating the wheels, when the shoes are just touching the drums. The small amount of trouble is amply repaid by efficient braking.

Camshaft Levers

The $\frac{1}{2}$-in. thickness of the brake liners makes it desirable to reset the camshaft levers relative to the cams when the liners are half worn.

This is necessary to prevent the levers from pulling past the most effective position when applying the brakes, with a resulting loss in leverage and braking efficiency. With single-servo brakes the levers on all wheels require resetting; on all other models the rear wheels only.

Slack off the adjustment for hand- and foot-brakes and disconnect the ribbons or rods from the camshaft levers. Remove the clamp-bolt, mark both lever and camshaft, and slip the lever off the camshaft. Replace the lever with mark on the lever five serrations back from the mark on the camshaft, and tighten the clamp-bolt.

Couple up the ribbons or rods and adjust as outlined above.

Access to the front camshaft levers on single-servo machines is gained by removing the aluminium cover above the king-pin.

Overhaul

When the liners have worn down to $\frac{3}{32}$ in. it is time to reline. In most cases the brake shoes can be removed without disturbing the hubs.

TITAN BRAKES

The braking equipment on this machine is a combination of the vacuum-servo and Lockheed hydraulic systems. Adjusters are fitted in the brake shoes, which are mounted on eccentric fulcrum pins. The liners are $\frac{1}{16}$ in. thick. A half-turn should be given to the eccentric pins when the liners are half worn. A single pair of aluminium-alloy shoes is used on each wheel, the hand-brake being arranged to pick up the single cross-shaft and apply the rear brakes only.

The foot-brake pedal is connected to the servo by a ribbon and adjuster, the push-rod for the hydraulic master cylinder being connected to the reaction lever of the servo. The length of the ribbon should not be altered.

Shoe liners can be seen through inspection doors on brake back-plates. To adjust the fulcrum pins when the liners are half worn, on rear wheels take out the split-pins and remove the locking plate. With a spanner give a half-turn to each of the fulcrum pins. Replace the locking plate and split-pins.

On front wheels remove the split-pins and slotted nuts. Take off the locking plate, give the fulcrum pins a half-turn. Replace the locking plate, tighten and split-pin the nuts.

Adjustment of Brakes

Adjustment is effected by turning the worm shafts with a screwdriver. Jack up the wheels and turn the adjuster with a screwdriver in the slotted end of the worm shaft. The clearance between the liners and brake drum should be not less than ·015 in. The adjusters should be turned clockwise on offside wheels and anti-clockwise on nearside wheels to expand the shoes.

LINX BRAKES

The braking system on this vehicle embodies Girling wedge-operated self-centring shoes, hydraulically applied in the case of the foot-brake. In the case of the hand-brake, which operates only on rear wheels, application is by mechanical means, full compensation between the wheels being obtained by a swinging mounting secured on the rear axle.

Only one adjustment is provided, and that is direct on the brake shoes. A square-headed stud is provided on each backplate to adjust the shoes. Turn this stud with a spanner in a clockwise direction until resistance is felt, then slack back one notch, which can be both felt and heard. All adjusters operate in a clockwise direction. It is not necessary to jack up the wheels.

TITAN, BEAVER, AND OCTOPUS ROAD SPRINGS

Lubrication

Grease should not be used for lubrication purposes ; gear oil should be used in all cases, except for the rear-spring pivot bearings on six- and eight-wheelers, in which case engine oil should be used.

When docking, the vehicle should be jacked up under the frame, the springs cleaned and then painted with heavy oil, which will work into the springs in service.

Spring Shackles

An adjustment is provided for taking up play between the spring eye and the shackles or brackets. Excessive side play should not be allowed to develop at these points, and the adjustment should be carried out at every dock.

Slack off the clamp-bolts and remove the split-pins locking the adjusting nuts. Screw up the adjusting nuts until tight, then slack back one half-turn to give running clearance. The slots in the shackle pins are elongated to allow the necessary relative movement between the clamp-bolt and shackle pin. Play is taken up at the anchored end by a flanged bush. The spring eyes must not be nipped. Replace the split-pins and lock up the clamp-bolts ; the clamp-bolts must always be kept tight. Alternative split-pin holes are provided for locking the adjusting nuts.

On the rear springs of four-wheelers the shackle is mounted on a cross-tube. In this case, play at the pivot end of the shackle is taken up by releasing the tab washer and tightening the setscrew. The setscrew must be locked with the tab washer after making the adjustment.

Spring Bolts

The springs are secured to the axles or spring-seat brackets by alloy-steel U-bolts. It is essential that these are always kept dead tight ; inspect for tightness after the first 500 miles, and then at every dock.

The nuts are prevented from slacking back by shake-proof washers; the split-pins in the bolt ends are to avoid losing the nuts if they are slackened off. The only exception is on the rear springs of multi-wheelers, in which case the nuts are split-pinned.

The nuts may become slack due to slight stretch in the U-bolts or bedding down of the spring leaves. Loose spring-bolts will result in spring breakage and undue wear; brake judder can also arise from the same cause.

Inspect the springs periodically and replace any broken leaves.

On Titan chassis it is important that the U-clips securing the anchor plates to the spring are not tightened solid, as this will result in harsh riding. A clearance of at least ·015 in. must be allowed between the anchor plate and the top leaf of the spring when the vehicle is unladen.

If the rear spring has been removed from the spring-seat bracket of six- and eight-wheelers (Beaver and Octopus), it is essential that the U-bolt nuts are pulled up dead tight when replacing. The nuts should be tightened evenly, using a 4-ft. bar.

If a renewal is necessary, the needle bearings can be removed by taking off the wearing plates after removing the setscrews with the small key provided. The outer races can then be driven out of the spring-seat bracket.

When fitting new bearings, care must be taken that the needle rollers do not fall out. Tap the bearing well home into the recess, retaining the needle rollers by holding the inner race in position. Turn the seat bracket over and insert the distance-piece and the other bearing, then fit the wearing plate, tightening the screws evenly. Turn the assembly over and fit the other wearing plate. The assembly can now be handled without risk of losing the rollers.

Fit the inside thrust-washer and check that the felt washer is in its groove. See that the cross-tube is clean and smear it with oil. Support the spring with the front end on the ground and the bearings in line with the cross-tube. Ease the spring with a bar inserted through the bearings into the cross-tube until it can be pushed on to the cross-tube. The inner races and distance-piece are a push-fit on the cross-tube, and they must be lined up correctly and pushed on without using undue force. Light blows with a heavy block of wood will help.

Replace the outer felt washer in its groove, fit the thrust-washer, and tighten the ring nut hard. The spring should oscillate freely without end play. If play is excessive, fit new wearing plates or carefully grind the end of the distance-piece. If too tight, check that the bearings are driven well home in the recesses and that the wearing washers are tightened properly. Fit the locking plate, replace the setscrews, and give a good supply of engine oil through the nipple.

Replace the shackle pins, locking with the lock washers and clamp-bolts, and connect up the brake rods, propeller shaft, and radius rod.

Reassembling Springs

When reassembling springs after replacing a broken leaf, see that each leaf beds correctly at the tips and that the leaf clips are replaced. The replacement leaf should be obtained from a Leyland service depot.

At overhaul, springs should be dismantled and retempered. It is strongly recommended that broken springs and springs for retempering should be returned to a Leyland service depot, to ensure correct treatment and rebuilding.

Before replacing springs, make sure that the eyes are dead in line; the shackle pins should not be forced in. Except in the case of multi-wheeler rear springs, the springs should be mounted on the axle and the spring eyes checked for alignment; if they are out, the shackle pins cannot be replaced and the springs should be retempered and correctly set. The rear-spring U-bolts must be pulled up dead tight, using a 4-ft. bar. Tighten the nuts evenly, adjust all shackle pins, and tighten all clamp-bolts.

LINX ROAD SPRINGS

Grease must not be used for lubrication purposes; gear oil should be used in all cases.

An adjustment is provided for taking up end play on the shackle pins. This adjustment should be carried out when docking. To adjust the pins, slack off the clamp-bolt nearest to the slotted nut, remove the split-pin, and tighten the nut. Slack back one half-turn to give running clearance, replace the split-pin, and tighten the clamp-bolt.

Spring bolts are treated in the same way as described for Beaver vehicles.

THE MORGAN 4/4 CAR

THE following notes relate to the Morgan 4/4 cars from 1936 to 1939.

Transmission

The only parts of the Hardy Spicer universal joints subject to wear are the journal and roller-bearing assemblies. When for any reason it becomes necessary to replace them, there is no necessity to remove the shaft from the car.

Remove bolts from companion flange at gearbox end of shaft and unscrew sleeve-yoke assembly. Then to dismantle :

(1) Remove snap-rings by pinching ends together with a pair of pliers. If a ring does not readily snap out of the groove, remove enamel from the yoke holes and tap the end of the bearing lightly, which will relieve pressure against the ring.

(2) Holding the joint in one hand, tap gently with a piece of copper or copper hammer on the radius of the ear of the yoke. The needle bearing will gradually emerge and can finally be removed with the fingers. Be sure to hold the bearing in a vertical position, and when free remove race from bottom side so as to avoid dropping the needle rollers.

(3) Repeat this operation for the opposite bearing.

(4) Support the two exposed journal pegs on lead blocks (to protect ground surface) and tap the ears of the flange yoke to remove the race.

(5) Reverse assembly and repeat the operation.

(6) Wash all parts in petrol.

(7) If parts are not worn, repack with a good grade of semi-fluid lubricant (160 S.A.E.). Make sure that the journal oil channels are filled with lubricant. With the rollers in position fill the race about one-third full.

Should any difficulty be encountered when assembling rollers in housing, smear the wall of the race with Vaseline. It is advisable to install new gaskets and gasket retainers on the journal assembly. The journal shoulders should be shellacked prior to fitting retainers, so as to ensure a good oil seal. It is also useful to have snap-rings available as replacements in the event of damaging a ring in dissembling the joint.

To Reassemble

(1) Insert journal in flange-yoke holes.

(2) Using soft round drift with flat face about $\frac{1}{32}$ in. smaller diameter than the hole in the yoke, tap the bearing into position.

(3) Repeat this operation for the three other bearings.

(4) Replace snap-rings, and be sure that these are firmly located in the grooves.

When assembled, if joint appears to bind, tap the lugs lightly with a wooden mallet, which will relieve any pressure of the bearing on the end of the journal.

Do not use grease in Hardy Spicer needle-bearing joints, as it is liable to clog the oil passages.

Rear Axle

All adjustments that may be necessary from time to time can be made without removing the complete axle from the chassis.

Differential adjustments are made after removing the differential and pinion housing from the axle case. Hubs, hub-bearing cups, and axle shafts are first removed. Bevel-pinion adjustments call for removal of propeller-shaft flange, oil retainer, thrust cover, and extraction of bevel pinion with races in position. The method of adjustment is by pressing off the ball race and inserting shims if the pinion is to be adjusted "in," or removing shims to adjust "out." The crown-wheel is adjusted by inserting a square bar in the slots on the differential-bearing locknut, after slackening off differential cup bolts and turning back the locking tabs.

When setting crown-wheel and pinion, endeavour to obtain a marking about $\frac{3}{8}$ in. along the inner portion of the tooth. If possible, run the gears at about 1,000 r.p.m. with some raddle or surface blue on the teeth. Apply load by holding a stout stick against the crown-wheel.

When rewiring the differential cup bolts, make sure that the wire passes over the locking tabs to keep them in position.

Hub bearings can be adjusted by insertion or removal of shims between cups and brake anchor plates after taking off hubs and drums. Adjust until there is the smallest amount of play possible, allowing the shafts to turn freely.

Use a new joint washer when refitting differential assembly.

Brakes

Front brakes are arranged to come on slightly before the rear. There is no alteration for this setting. Adjusters are provided for taking up slack in cables, but no attempt should be made to take up more than stretch. Adjustment is made at adjusters on backplates. See (7) below.

Relining

(1) Jack up the car in the manner previously described and remove road wheels.

(2) Remove drums. The rear-wheel drum is secured by two countersunk screws; remove these screws and the drum can be tapped off, disclosing the brake shoes, etc. In the case of the front-wheel drum, it is

necessary to remove the complete hub, and this can be done only by the use of a suitable drawer.

(3) To dismantle the brake. All that is required is a large screwdriver. With this it will be found quite easy to prise one shoe out of the groove in the plunger at expander end. Both shoes and springs can now be removed, leaving expander and adjuster units in position on the backplate. Be careful not to overstretch the spring when removing shoes.

(4) Clean down the backplate and check expander and adjuster units for free working. Slacken back adjuster (anti-clockwise) to full "off" position. Adjuster cone spindle should screw quite easily into housing. Inspect shoe pull-off springs, and replace if stretched or damaged.

(5) Detach springs from old and refit to new shoes. Be sure that the springs are between shoe webs and backplate, otherwise shoes will not lie flat on plate. Keep all grease off brake linings. Place shoes with springs attached against backplate. Fit shoe ends to adjuster grooves. Shoes have half-round slots at one end; fit these slots to the adjuster plungers; then insert other end of shoe in expander plunger. Insert screwdriver under web of remaining shoe and ease into plunger groove.

(6) Refit drums. Be sure they are clean and free from grease, etc.

(7) To ensure correct clearance between shoes and drums, slacken off set-pins that hold adjuster to backplate one complete turn, and lock up brake shoes in the drum by turning the adjuster in a clockwise direction. Bolt up adjuster set-pins tightly and slacken off adjuster to nearest notch. Give the brake pedal a firm application, to ensure that the shoes have centralised. Drums should now be quite free.

(8) Refit road wheels and jack down. The operation of relining is now complete, nothing further being required.

Important

Do not tighten up the brass expander nuts on outside of backplate. Do not handle linings with greasy hands. Do not overstretch shoe pull-off springs when removing shoes. Do not remove expander and adjuster housings from backplate. Do not forget to tighten up firmly adjuster-housing set-pins. Do not fit any other than "Girling" replacement shoes, which are correctly riveted and ground to correct periphery, ensuring a fast and easy bed-in to drum.

Steering and Front Suspension

The front wheels are suspended independently on spiral springs, and slide vertically on the main axle pins that hold the complete assemblies in position. The sliding axles, wheel spindles, and brake plates form complete units and require no other attention than that of lubrication. Phosphor-bronze bushes are pressed into the sliding axles. New bushes become necessary with wear, but a period at which renewal should be made cannot definitely be laid down.

The method of dismantling is simple, and is carried out in the following manner :

Jack up front of car to a height of at least 15 in. and remove road wheels. Remove pins from track-rod ends (while out, clean off and wipe over with damp oily rag) ; uncouple shock absorbers (take this opportunity of replenishing liquid if required), slacken off and remove nuts over top end lugs of cross-axles. The vertical axle pins can then be drawn down and out, when assemblies with hubs complete can be removed. When reassembling see that all nuts are tight and properly cottered. Do not reassemble track-rod pins in oil ; excess lubricant negatives their damping properties. Check wheels for alignment. Errors in misalignment can be corrected by adjustment of the track rod, the ends of which are threaded for the purpose. Toe-in should not exceed $\frac{1}{8}$ in. Toe-out is to be avoided. Rear wheels should be parallel.

The steering column calls for no attention beyond occasionally removing the plug from oil filler and refilling with oil. The drop-arm connecting drag link to column fits on a spline. If at any time it is removed, care should be taken to see that it is again fitted to the correct serration. Adjustment which requires no explanation is provided at either end of the drag link when found to be required.

Bodywork

The body is held down on chassis by seven bolts each side. To remove, take out bolts, remove steering-column clip, remove pedal board, and disconnect wiring. To remove petrol tank from two-seater, the two rear bolts on each side of wooden frame underneath have to be taken out. This allows frame to hinge on front bolts and to drop sufficiently to allow neck of filler to clear panel.

Shock Absorbers

The filling of the shock absorbers is a comparatively simple matter, which is carried out in the following manner :

Remove the shock absorber from the brackets.

After drawing off dust cover, grip cylinder by square peg in a vice, unscrew the main gland, draw the piston out of cylinder, empty out old liquid, refill to within about $\frac{1}{2}$ in. of the top, replace gland, push up slightly, and carry out the test explained below to prove that there is the correct amount of liquid in the cylinder. After correct amount has been determined, tighten gland finally.

It is essential that a test should be carried out to ensure that the absorber is not overfilled, by holding the cylinder and gripping the square piston rod in a vice ; make sure that it will compress to its maximum amount. If there is too much liquid in the cylinder it will be possible only to compress the absorber to half or three-quarters of its full stroke,

in which case a little of the emulsion must be removed so that the absorber will just compress to its maximum.

On the contrary, should the absorber go to its full stroke and easily bottom, add a little more emulsion until the absorber will compress to within about $\frac{1}{4}$ in. from the end of the stroke. We may mention that it is not a particularly important factor if the absorber is a little short of liquid, but it is most essential that overfilling be avoided, as this results in the stroke being limited, and the springs will not be allowed to flex.

Rear Shock Absorbers

The André multiplex shock absorbers fitted to the rear are set to a certain initial tension before they leave the factory. No change in this adjustment should be made until the car has been driven about 100 miles on good and bad roads, and at no time should the shock absorbers be adjusted up dead tight.

Carefully note the riding qualities of the car. If the spring action seems too free, increase the friction resistance of each shock absorber by turning the centre adjusting nut to the right, or clockwise, by not more than one graduation at a time.

If the spring action seems too retarded and feels stiff, reduce the frictional resistance again by turning the adjusting nut to the left, or counter-clockwise. Careful adjustment in this manner will produce an ideal condition. The springs will still have the required amount of flexibility for easy riding, but spring vibration will be reduced to a minimum and violent rebound effectively eliminated.

Readjustment may become necessary only after several thousand miles of car travel, and should be made only when the spring movement seems too free, and then the indicator should be moved not more than one-half of a graduation at a time.

It should be noted that the full benefit of the shock absorbers will not be felt when the car is travelling at low speeds, as under these conditions the spring movement is very limited, but as the speed increases their effect becomes more pronounced, especially over bad roads, when the spring action is most severe. Testing and adjustment should, therefore, be carried out at comparatively high average touring speeds.

The frictional resistance required to effectively control the action of the springs is comparatively small, and care should be taken not to increase the pressure more than is absolutely necessary when adjusting to obtain the desired results. The initial factory setting of the shock absorbers is approximately correct under normal conditions, but for road and track racing a considerable increase in pressure may be required.

Rear Springs

If removed, examine Silentbloc anchorages and renew if worn. See that trunnions in rear chassis cross-member are refitted with solid half at top.

THE SCAMMELL MECHANICAL HORSE

THE Scammell Mechanical Horse is a five-wheeled articulated vehicle, consisting of a three-wheeled motive unit and a two-wheeled trailer superimposed at its forward end on the motive unit. The following notes relate to all models, unless otherwise stated.

STEERING AND FRONT WHEEL

The steering wheel rotates the vertically mounted front fork by means of spiral gearing which consists of a hardened steel worm and a phosphor-bronze worm wheel. Castor action is provided. The front fork and steering arms are steel stampings. The reduction ratio is approximately 12·5 to 1; on the earlier type it is 6 to 1.

Use "Shell" gear oil for lubricating the steering gear. Fill to top of filler orifice. The capacity is approximately 1 pint.

To Remove Steering

Remove the front mudguard grille, jack up the front of the motive unit, and remove front wheel.

The chassis must be lifted about 5 in. *after* removal of the two nuts which secure the hub spindle to the spring arms. By manœuvring the wheel it can be withdrawn complete with the hub. Under the arch of the forks will be found a slotted nut which secures the forks to the pivot pin; remove this nut and give the forks a sharp blow downwards to free them from the taper on the pivot. Remove the key from the pivot pin. Support the petrol tank and disconnect the tank brackets from the steering box. It is now necessary to split the steering box by removing the setscrews which connect the box to the pivot housing. Have a tray and some rag ready to catch the oil, and carefully raise the box assembly clear of the pivot-pin top. The bolts holding the pivot housing to the chassis can now be removed and the housing removed from the chassis.

When replacing the steering make sure that the forks are put up with the dampers to the front and the large springs to the rear, as there are two bosses at the top of the forks which act as stops in conjunction with two round-head bolts in the front cross-member.

On earlier models a plate was held in position under the pivot housing to act as a stop; this must be replaced in its correct position. When reassembling the steering head, ensure that the shims are replaced under the thrust-race cap to allow a free running fit of the pivot pin. If the steering is stiff or heavy, check the front-tyre pressure, which should be 50–55 lb.

Oil leaks from the bottom of the steering case on to the front tyre will usually be cured by lowering the oil level by $\frac{1}{8}$ in. or so. If this does not effect a cure, a new steering-pivot bush must be fitted.

To Remove Tyre from Rim

These instructions apply to all sizes of tyres fitted to the "mechanical horse" except 34 in. × 6 in., which is of the loose-flange and spring-ring type. The wheels are built up in two halves and joined together with bolts round the central flange. Always deflate the tyre before removal from the hub.

Remove the collar nuts from the wheel studs—offside right-hand thread, nearside left-hand thread—and remove the wheel from the hub. The rim is now split by removing the nuts on the bolts round the central flange. Care should be taken when reassembling the wheel to make sure that the valve groove in the one half coincides with the valve hole in the other half.

To Dismantle Front Hub

Remove the oil retainers and covers from each end of hub, drive out the spindle from either end. This will come out complete with one race; the other race is removed by means of a drift inserted through the hub.

Note ball races when reassembling. If the word "thrust" appears on the rings, it will denote that they are dual-purpose races and must accordingly be assembled and refitted with this marking on the *outside* of each end. Having assembled the hub, it should be checked to ensure that the spindle has from ·005 in. to ·010 in. end float. If new races are fitted, these must be from a "push" to a light tapping fit on the spindle.

Front Shock Absorbers

These should be adjusted by means of the nuts under the two spiral damper springs on each side of the hub. To replace the friction linings—remove the front and rear covers, take the weight of the unit on a jack under the front cross-member, and remove the side plates. After removing the drums, the plates to which the linings are attached can be dismantled. When reassembling, ensure that the grease ways are all clear, and thoroughly grease all parts prior to replacing.

Adjustment of Steering-column Races

If at any time it becomes necessary to take up end play in the steering column, proceed as follows: The nut which retains the steering wheel to the column has a screwed peg running through the centre of it, secured by a split-pin through the nuts. Remove this split-pin and unscrew the nut a few turns, slacken the $\frac{1}{2}$-in. bolt clamping the steering wheel to the column. Screw out the peg in the centre of the nut by a quarter-turn,

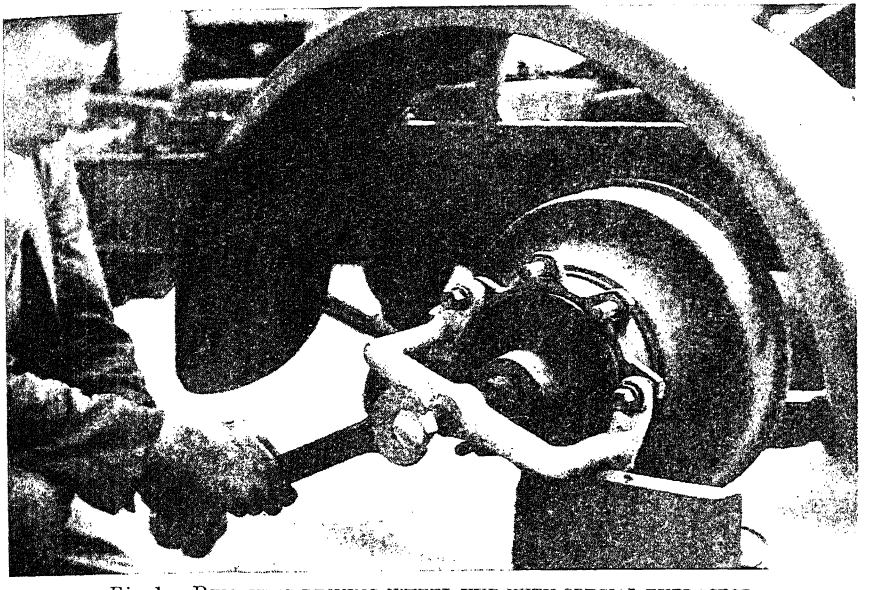


Fig. 1.—REMOVING DRIVING-WHEEL HUB WITH SPECIAL EXTRACTOR

and then tighten up nut and peg together. Give nut a sharp blow with a hammer or mallet to free the ball races.

If the end play is not completely removed, repeat the operation, giving a quarter-turn to the peg each time until all end play is taken up. Finally, split-pin the nut and peg and retighten the wheel-clamping bolt.

PROPELLER SHAFT

Hardy Spicer type propeller shafts are used, incorporating their K.R. type universal joints. The following size joints are used: M.H.3—1,250; M.H.6—1,300. The trunnions and needle-bearing assemblies are the only parts subject to wear, and should it become necessary to replace these at any time, the design is such that correct assembly is a very simple matter. No hand fitting or special tools are required.

To Dismantle

To dismantle, commence by removing the lock rings which hold the needle bearings in position. This is done by squeezing them together with a pair of pliers. To remove the needle-bearing assembly, first remove the burrs and paint around the edge of the hole, then tap the yoke sharply with a mallet at a point near the bearing, which will then drop out. Do this for each bearing; it will then be found possible to remove the journal.

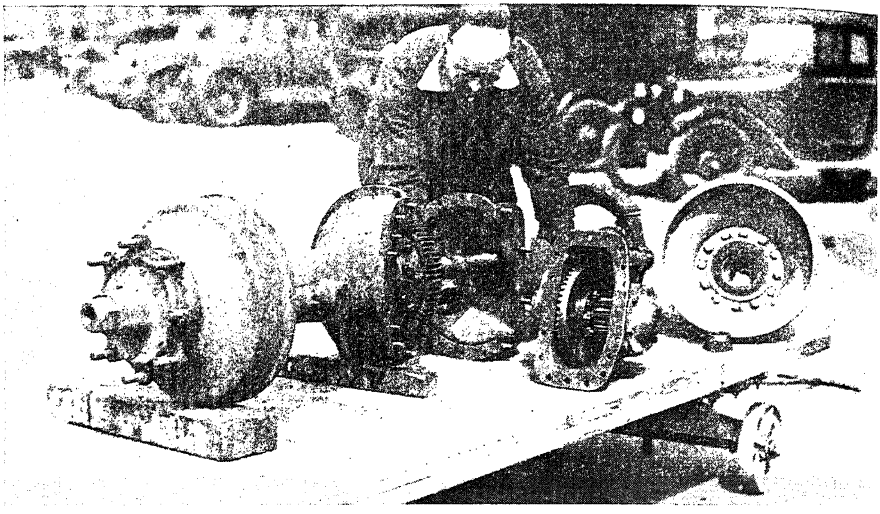


Fig. 2.—DISMANTLING DRIVING AXLE OF MECHANICAL HORSE

The distance-pieces on each side of the ball races must be marked to ensure their replacement on the same side on reassembling.

Reassembling

To facilitate reassembling the bearings, the needles should be lightly smeared with a thick oil or vaseline to hold them in the race. Hold the trunnion in vertical position and press the bearing into the yoke from the bottom ; this should prevent the needles from falling out.

If the clip joint is removed from the shaft, care must be taken to reassemble so that the sleeve-yoke lugs lie in the same plane as the stub ball-yoke lugs. Arrows are stamped on the sleeve and shaft for this purpose. Transmission vibration has been traced to incorrect assembly of these components.

It will be appreciated that, due to the low axle ratios necessary with this type of vehicle, the speed of the propeller shaft is much higher than on normal-type vehicles, so that to ensure trouble-free running, regular lubrication of the joints is necessary.

Lubrication

The trunnion cross on the later-type models (fitted to vehicles delivered after 1st August, 1937, approximately) is provided with a large interconnected oil reservoir in each end. These reservoirs are filled with lubricant at the time the joints are assembled, and should require replenishing only at intervals of 15,000 miles or when the vehicle is overhauled, whichever is the more frequent. To do this, one needle-bearing assembly should be dismantled, when by holding that journal upright the joint may be filled with lubricant.

In the case of the older types of propeller shafts (on vehicles delivered before 1st August, 1937, approximately), where the reservoirs are not inter-connected, the joints should be dismantled, cleaned, and replenished with oil every 6,000 miles. Messrs. Hardy, Spicer Ltd. recommend the use of 160 S.A.E. oil (Shell gear oil or Spirax heavy) for both types.

DRIVING AXLE

The driving axle is of the double-reduction type, incorporating four-pinion differential, high-tensile-steel alloy spiral bevel and spur gears. The axle shaft is of the three-quarter floating type, with stamped hubs run on ball bearings.

Alternative axle reduction ratios are available as under :

M.H.3

Approximate ratio of	9·25 : 1	M.H.6/3 motive unit
,, ,,	10·28 : 1	Standard 3-ton loads
,, ,,	12·33 : 1	Refuse collectors with special loads of 4 tons or in hilly districts
,, ,,	14·51 : 1	3/6-ton carrier (6-ton load)

M.H.6

Approximate ratio of	13·23 : 1	Standard 6-ton loads
,, ,,	17·11 : 1	Special loads up to 10 tons
,, ,,	19·44 : 1	10-ton loads in hilly districts
.. ..	22·51 : 1	Exceptional cases

Driving and braking torque is taken by semi-elliptic springs.

Lubrication

Use " Shell " Double Oil. Fill to top of filler at rear of axle, not by brass inspection plug.

Removal of Axle from Chassis

Disconnect brake rods and rear end of propeller shaft ; jack up rear of chassis frame in front of axle under both side members. Remove wings, shackle pins, and shackle bolts. The axle can then be wheeled out from under chassis.

Dismantling Driving Axle

Detach front gear casing from main-axle casing, take off axle-shaft nuts, and withdraw hubs by means of a special extractor. Remove keys from tapered ends of shafts. Remove bolts from axle casing and lightly tap casing apart. Care must be taken to note the distance-pieces which are fitted either side of ball races ; these must be correctly replaced when reassembling.

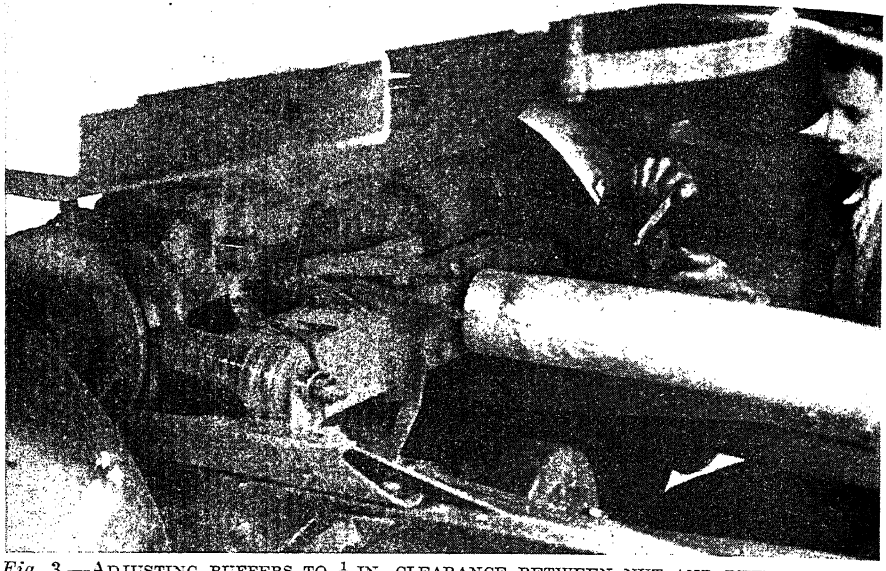


Fig. 3.—ADJUSTING BUFFERS TO $\frac{1}{8}$-IN. CLEARANCE BETWEEN NUT AND BUFFER BRACKET WITH UNIT COUPLED TO CARRIER

To Remove Large Spur Wheel

Take out bolts and lightly tap off wheel which is spigoted on to the cage. Take away bolts which hold two halves of cage together, then remove differential spider and pinions. The axle shaft with bevel can now be drawn out from the cage.

To Dismantle Front Gear Casing

Take off spur-pinion caps, the offside one of which may incorporate the mileometer or speedometer drive, and the nearside one the speed pilot. Note carefully the number of shims fitted to each cap, for re-assembling purposes. Remove the nuts from the spur-pinion shaft, drive out shaft by striking from the *nearside*; it will then come through complete with the offside ball race. Remove the nearside ball race by means of a drift inserted through casing. The bevel wheel and spur pinion can now be removed.

M.H.3

To remove bevel pinion, take out setscrews holding transmission brake drum in position, then remove brake-shoe fulcrum pins. The fulcrum bracket should be dismounted by removing the setscrews which hold it to the gearcase. Disconnect wire and take out ball-race locking screws from nearside of gear casing. The bevel pinion can then be tapped out, complete with ball races.

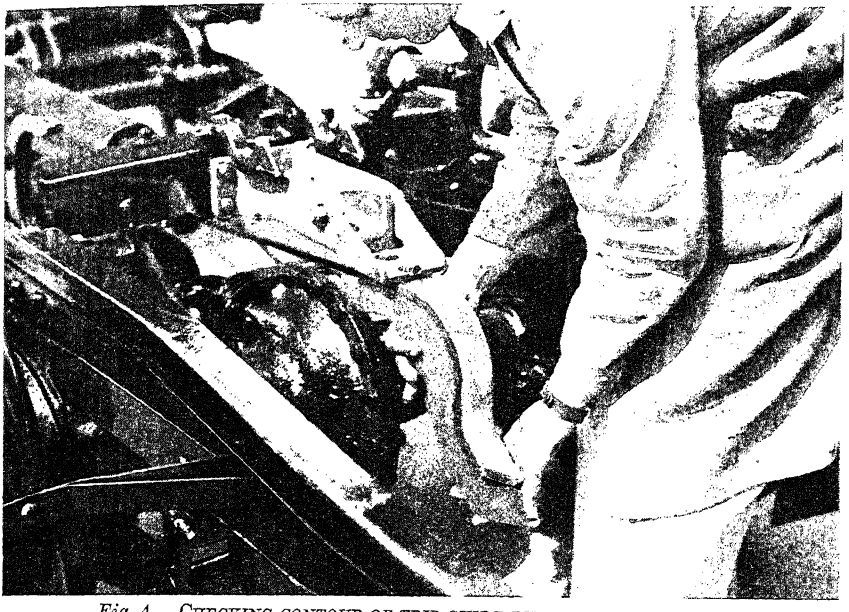


Fig. 4.—CHECKING CONTOUR OF TRIP GUIDE BY MEANS OF TEMPLATE

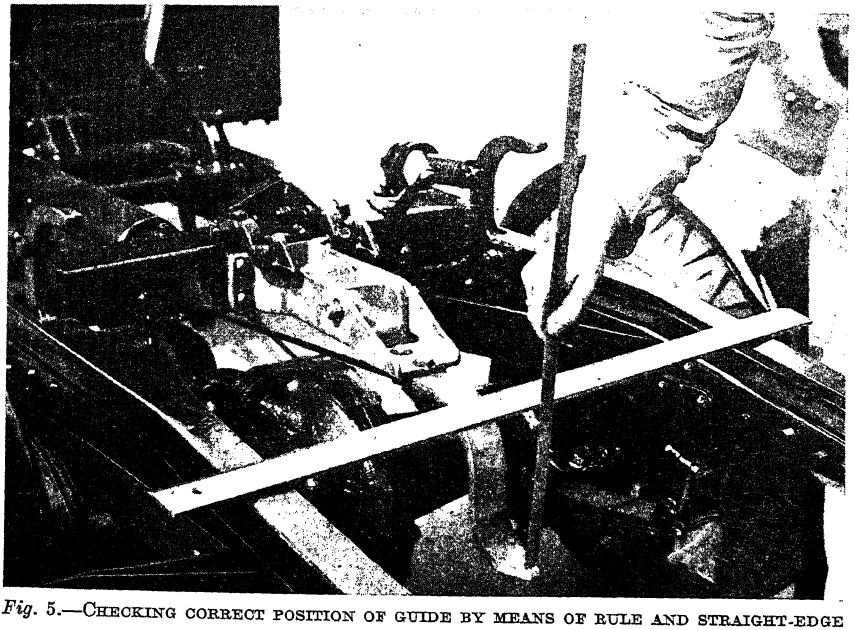


Fig. 5.—CHECKING CORRECT POSITION OF GUIDE BY MEANS OF RULE AND STRAIGHT-EDGE

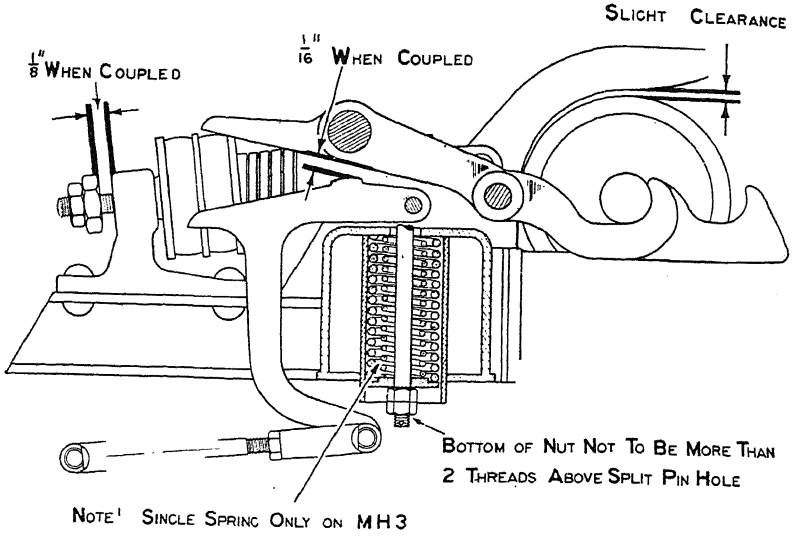


Fig. 6.—COUPLING GEAR ON MOTIVE UNIT, SHOWING NECESSARY CLEARANCES

M.H.6

Proceed as with M.H.3 with regard to transmission brake-drum fulcrum pins and fulcrum bracket. Take out the eight setscrews which retain bevel-pinion housing to gear casing. Screw two $\frac{3}{8}$-in. B.S.F. setscrews in tapped holes provided in flange to extract pinion housing, taking care to note the number of shims fitted under flange. Remove nut from splined end of bevel pinion, and take off driving flange ; a slight tap with a mallet on the pinion will drive out pinion and races complete.

In the event of oil leaking into the transmission brake drum, the fault will be found in the oil seal fitted into the fulcrum bracket. The fulcrum bracket should be removed as previously described and the oil seal gently tapped out, taking care to avoid damaging it. If the leather of the seal is in good order, coat the outside of the oil seal with jointing compound and tap it carefully back into position with the turned-up edge of the leather facing *inwards*, afterwards slightly peening the edge of the housing with a punch to hold the oil seal in position. The setscrews in the fulcrum bracket must not be pulled up too tightly or the bracket will distort, thereby allowing the oil seal to rotate and oil leakage to occur.

COUPLING GEAR AND UNDERCARRIAGE

The front portion of the carrier is fitted with a turntable, to which is attached a retractable undercarriage carrying two wheels which support the carrier and render it mobile when detached from the motive unit.

On the rear of the motive-unit frame are two ramps, or runways,

which are so shaped as to take the flanged wheels fitted to the transverse oscillating beam on the carrier undercarriage at whatever angle you may desire to couple the unit to the carrier. At the front end of the ramps are fitted two adjustable spring-cum-rubber buffers. These buffers take the shock of coupling up, and load the coupling hooks to keep the carrier securely locked to the unit.

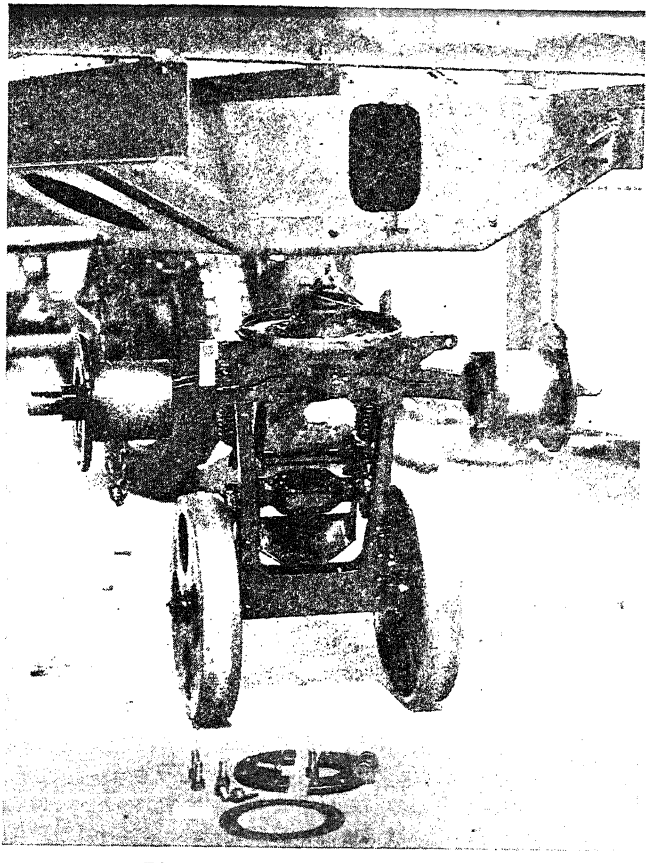


Fig. 7.—UNDERCARRIAGE REMOVED
Showing the horseshoe locking plates and shims for taking up excessive play.

Lubrication

Grease all joints on the undercarriage once weekly, and where no grease-nipples are provided give a few drops of oil. Lubrication of this assembly is of the utmost importance, since any tightness in the joints may cause collapse of the carriers, with consequent risk of personal injury.

The joints of the coupling hooks and operating gear must also be given attention with the oil-can at similar intervals to ensure ease of operation.

Adjustment of Buffer Springs

The locknuts in front of the buffer brackets should be set with $\frac{1}{8}$-in. clearance from buffer bracket when unit is coupled to carrier (*see* Figs. 3 and 6).

Correct Position of Guide

The guide should be checked for shape and position by means of the template provided (*see* Fig. 4), and also with a rule and straight-edge, for the purpose of ascertaining that the following dimensions are maintained (*see* Fig. 5).

M.H.3

Distance from rear cross-member of motive unit to point of guide—1 ft. 10 in. Distance from top of ramps to guide point—$7\frac{7}{8}$ in.

M.H.6

Distance from rear cross-member of unit to point of guide—2 ft. $3\frac{3}{16}$ in. Distance from top of ramps to guide point—$10\frac{5}{8}$ in. (*see* Fig. 5).

When the unit is coupled to carrier there should be a clearance of $\frac{1}{16}$ in. between the uncoupling cam and the bottom face of the locking hook on the motive unit rear cross-member (*see* Fig. 6).

Figs. 5 and 6 show the coupling-gear layout and some of the dimensions given above illustrated. On the later models a double locking hook has been introduced, which, used in conjunction with lighter buffer springs and a heavier twin-hook return spring, gives an increased safety factor when coupling up.

Removing Undercarriage and Turntable

Jack up front of trailer, disconnect the tail-lamp connecting wire inside the turn-table box-member.

Remove the pin which secures the brake-operating bellcrank to the locking plates. Take out the eight setscrews and remove the two horseshoe locking plates which secure the undercarriage to the box-member. The undercarriage may now be removed if the chassis is jacked up a little higher.

Taking up Wear

A rubbing plate is fitted to the underside of the box-member upon which the turn-table operates, and excessive wear on the undercarriage can be taken up by fitting shims of sheet steel between the rubbing plate and the box-member.

After shims have been inserted as above, turn-table should rotate evenly and without side play or rock.

When the unit is uncoupled from the carrier the undercarriage should immediately release and lower its wheels to the ground, and the spring catch lock round the pins protruding from the supporting arms.

Any failure or sluggishness in this operation is almost certain to be due to neglect in lubricating the various joints.

To rectify, either thoroughly spray with penetrating oil, or preferably

completely dismantle the undercarriage and ease all the pins. Clean all parts and grease well before reassembling. It is essential to uncouple the carrier at least once a week to inspect all joints and thoroughly lubricate the undercarriage.

Warning

Inexperienced persons should not be allowed to tamper with the under carriage when the carrier is uncoupled unless it is supported on trestles at its front end, as disturbance of the safety catch may cause collapse of the carrier, with consequent serious results.

THE CARRIER

This part of the vehicle is of such simple construction that no attention is required except regular lubrication of all parts, particularly the undercarriage, regular attention to the tightness of wheel nuts, and brake adjustment.

The carrier brakes are adjusted by means of the wingnuts on the balance-beam situated under the floor of the body.

In the event of its being necessary to remove the carrier hubs for brake relining or any other cause, remove wheels, hub caps, and axle nuts. Now withdraw the hubs with the same tool as used for the driving hubs. The brake shoes will now be exposed and can be removed without further trouble.

M.H.3

When refitting hubs, fill them with a liberal supply of grease and reassemble with bearings. Adjust by first tightening the locknut right up, then slacken back one-third of a turn, or two castellations, and insert split-pin.

M.H.6

In this case the locknut is also fitted with a clamping bolt and the axle is drilled with two split-pin holes. After tightening up the locknut, slacken back one and a half castellations before inserting the split-pin. Finally, retighten the clamping bolt.

REMOVING BODIES FOR FRAME REPAIRS

ALTHOUGH many repairs can be effected to the chassis without removing the body, this becomes necessary when frame repairs are required. As the modern body extends below the top of the chassis and the tank filler often passes through the rear wing or a part of the body, its removal is not so easy as with an older pattern of car, which has the bottom of the body level with the top of the chassis.

Preliminary Work—Dismantling the Body

To prepare the body for dismounting, the back cushion and all loose and fixed floor coverings are removed, then the front seats and all floorboards. The rear wings are detached from the body and platform steps. The removal of the front wings and running boards is not always essential for dismounting, but may be necessary, according to the work which has to be done on the chassis. If the front wings are to be detached, then the wiring of any wing lamps is disconnected. Other wiring which has to be disconnected includes that of all electrical equipment of the body, such as roof and other interior lamps, cigar lighter, and screen wiper, also head and tail lamp and rear number plate.

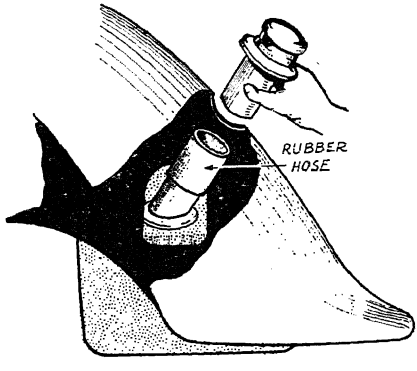


Fig. 1.—REMOVING THE UPPER PORTION OF THE TANK FILLER

This is sometimes connected to the lower part by means of a piece of rubber tubing.

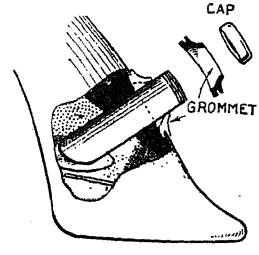


Fig. 2.—ANOTHER METHOD OF REMOVING TANK FILLER

In this instance the extended tank filler is in one piece and it is released for lifting the body by unscrewing the cap and removing the rubber ring or grommet.

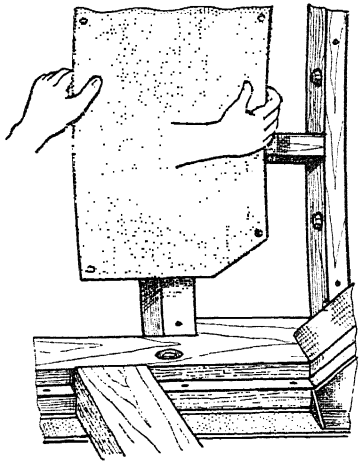


Fig. 3.—REMOVING THE INSIDE SCUTTLE PANEL

This is done in order to expose the side bolts which secure the front of the body to the dash.

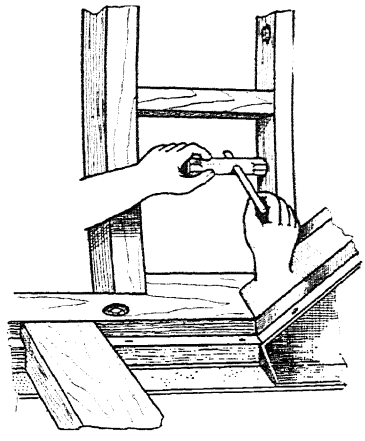


Fig. 4.—RELEASING THE BOLTS EXPOSED BY REMOVING THE PANEL SHOWN IN FIG. 3, WITH BOX SPANNER AND TOMMY-BAR

Facia Board, Control Levers, and Doors

The facia board is removed from its side brackets so that the instrument assembly remains attached by its own brackets to the dash. The brake and speed levers are arranged so as to form the minimum amount of obstruction to the body, which will be lifted vertically and to the rear, that is, the lever should be placed in an upright position. All doors are removed by driving out the hinge pins carefully with a drift. The hinge pins are replaced in the door half of the hinge so that they are not mislaid.

Releasing the Tank Filler

Attention is now directed to the tank filler. As a rule, this is one of two patterns. The filler may be extended by means of a rubber connection as shown in Fig. 1, so that the upper portion of the filler may be pulled out. If the filler passes through the wing, then the filler is, of course, detached before the removal of the wing. When the filler has no rubber connection but is a continuous metal tube, then it passes through an enlarged hole, as shown in Fig. 2. The clearance around this hole is concealed by a rubber ring or grommet, which can be sprung off by inserting the fingers under the rim at the edge, after the filler cap has been unscrewed.

Exposing the Dash Bolts

The body is held to the chassis by the bolts which pass through the side members of the frame or the mounting brackets, also by the bolts at the front which hold it to the dash. To expose all the dash bolts it is

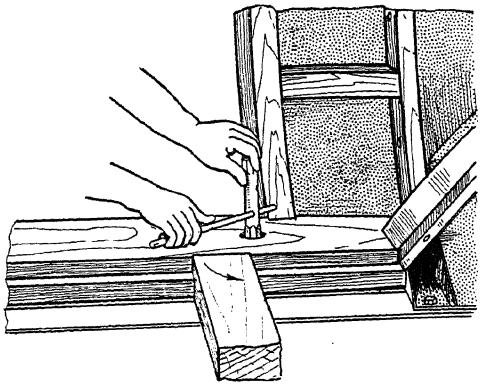


Fig. 5.—RELEASING THE HOLDING-DOWN BOLTS

usually necessary to remove an inside panel of plywood covered with leathercloth which is pinned or screwed to the side of the scuttle as shown in Fig. 3. The box spanner and tommy-bar (Fig. 4) will be required if the nuts of these bolts are recessed.

Removing the Holding-down Bolts

If the footboards which contain the pedal slots were not removed with the floorboards, these are now unscrewed, after which all holding-down bolts are released (Fig. 5.) The position of one of these bolts is shown clearly in the part sectional view, Fig. 6.

Preparing the Trestles

Before proceeding to lift the body, the necessary trestles which will form the temporary resting-place of the body are got together. The bottom of the body, whether a saloon, coupé, or open one, is higher under the wheelarch than in front, as shown in Fig. 11, therefore a pair of trestles should be available, one of which is about 6 in. higher than the other. It is an advantage if the body rests on these trestles horizontally so that the weight is properly distributed and the safety of the dismounted body ensured.

Dismounted Body should be Well Supported

Also, as the body is designed with a view to its shape being preserved by its attachment to the chassis, this shape is more likely to be maintained when it is removed from the chassis if similar means of support are provided. It is therefore an advantage if a third trestle can be placed under the centre of the body.

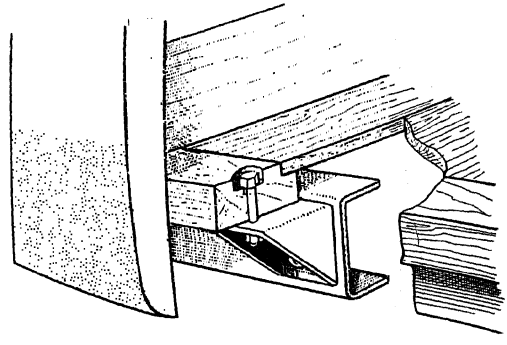


Fig. 6.—PART SECTION THROUGH CHASSIS AND BOTTOM OF BODY, SHOWING THE HOLDING-DOWN BOLT PASSING THROUGH THE BOTTOM SILL AND MOUNTING BRACKET

Instead of trestles a body-horse may be used, which is a low rectangular framework with lifting handles, or a trolley on castors. Lengths of timber of 2 in. by 2 in. and 2 in. by 1½ in. may be used to increase the height of the trestles or body-horse so that the body rests horizontally. These packing bars may be kept in position if a plate is screwed each side or encircles them so that overhanging lips are formed (Fig. 12).

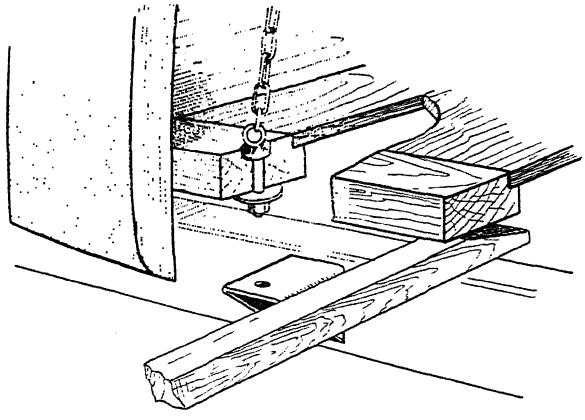


Fig. 7.—WITH THE HOLDING-DOWN BOLT REMOVED, THE HOLE IS THEN FREE FOR THE INSERTION OF THE RING BOLT OF THE LIFTING CHAIN

A large washer is placed on the underside. The ring bolt is inserted after the body has been raised and a bar of wood inserted.

First Stage of Lifting

The body must now be raised sufficiently to enable pieces of timber about 3 in. by 3 in. to be inserted between the bottom framework of the body and the chassis (Fig. 7). As the floorboards are removed, a convenient method of lifting the body for this purpose is for a man to step down inside between the chassis so that he may lift the body at a point where one of the cross bars joins the bottom side. The position of these crossbars is illustrated in Figs. 11 and 13. Another man lifts at the same point but on the outside, which will be at the foot of one of the pillars forming one side of a door opening.

Placing Two Bars between Body and Chassis

If sufficient men are available both sides may be lifted simultaneously, while another assistant inserts the length of timber. A pair of these bars are thus inserted, one in front close to forward edge of the door opening and the other under the centre of the wheelarch.

Lifting by Hand

If no lifting tackle is available, more men will be required, as the dismantled body will weight from 4 to 5 cwt. The pieces of timber which have been inserted under the body are used for lifting it. They should be long enough so that a man may lift each end. For a long and heavy body a third piece of timber is inserted at the base of the middle pillar of the body with a man at each end.

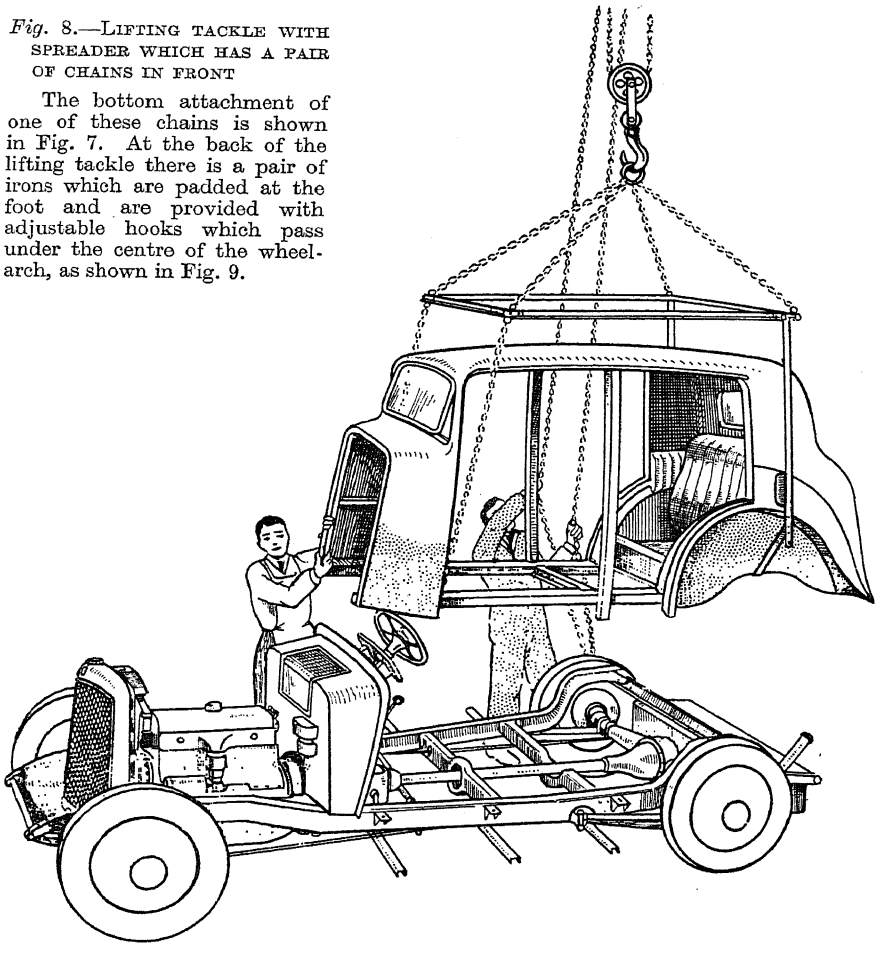


Fig. 8.—LIFTING TACKLE WITH SPREADER WHICH HAS A PAIR OF CHAINS IN FRONT

The bottom attachment of one of these chains is shown in Fig. 7. At the back of the lifting tackle there is a pair of irons which are padded at the foot and are provided with adjustable hooks which pass under the centre of the wheel-arch, as shown in Fig. 9.

Height of the Chassis

The body has to be lifted over the steering wheel, which is 3 ft. above the level of the top of the chassis or 4 ft. 6 in. from the ground level. The height the body has to be raised may be reduced a few inches by the removal of the steering wheel, the highest point then will be at the top of the instrument assembly. The actual amount the body has to be raised depends chiefly on the shape of the front of the body, and the wheelarch. In Fig. 11 the front of the scuttle is a plain arch, and usually the top of the steering wheel is only a few inches below it.

Lifting the Scuttle over the Steering Wheel

The body is lifted vertically for about 12 in., so that it is free at the base of the wheelarch. Then it may be lifted towards the rear, so as to clear the rear wheels, while, at the same time, the arch of the scuttle passes over the steering wheel. As a precaution the wooden bars which are used for lifting should be clamped or tied to the bottom framework.

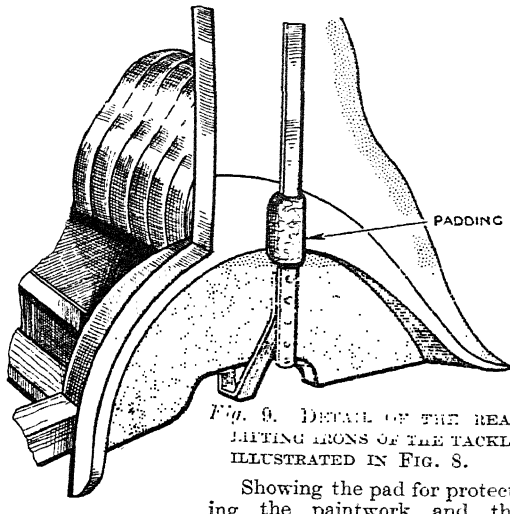


Fig. 9. DETAIL OF THE REAR LIFTING IRONS OF THE TACKLE ILLUSTRATED IN FIG. 8.

Showing the pad for protecting the paintwork and the adjustable hook.

Lifting Tackle with Spreader

Most garages and repair shops, however, have some form of lifting tackle, which simplifies considerably the work of dismounting the body. This tackle should include a spreader, as shown in Fig. 8. This is made of $1\frac{1}{4}$-in. angle iron and is about 5 ft. 6 in. long and 5 ft. 6 in. wide. Each corner of the spreader has a ring for the upper chains, which are assembled to the lifting ring. At the two front corners of the spreader is another pair of rings for the attachment of the lower front chains. At the back of the spreader is a pair of $1\frac{1}{4}$-in. by $\frac{1}{4}$-in. irons about 3 ft. 6 in. long. These irons are swivelled at the top to the spreader and are padded at the lower end (Fig. 9) in order to preserve the paintwork. The pad slides on the iron, so that its position may be adjusted as required. Below the pad the iron is drilled with holes about an inch apart, so that a hook may be

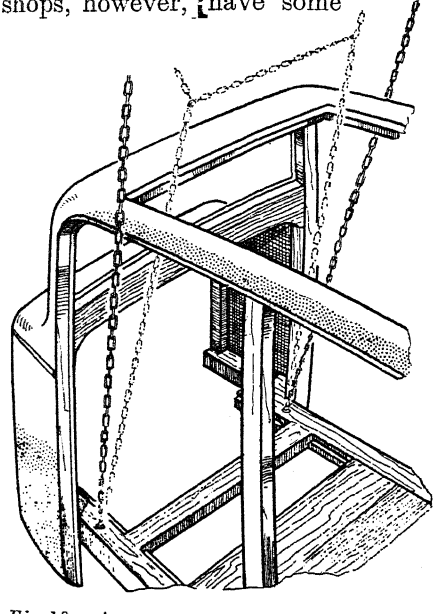


Fig. 10.—ALTERNATIVE METHOD OF LIFTING THE FRONT OF THE BODY WHEN IT HAS A SLIDING ROOF

The chains may be passed outside, as in Fig. 8, or inside as indicated by the dotted lines in this picture.

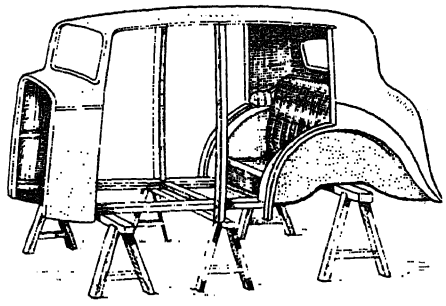


Fig. 11.—THE DISMOUNTED BODY RESTING ON ITS TRESTLES

The body should be adequately supported and in a horizontal position so as to prevent any distortion.

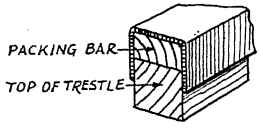


Fig. 12.—BAR FOR ADJUSTING THE HEIGHT OF THE TRESTLE

This bar has a plate screwed to it which forms lipped edges and keeps it in position.

bolted on the inside at the required height.

Attachment of the Tackle to Body

The lower end of the front chains are attached to the body by means of ring bolts and washers (Fig. 7). The same holes are used from which the holding-down bolts have been removed. The bolt end of the chain is dropped through the hole and bolted after placing the washer on the under side. The rear hooks and pads are adjusted at the rear so that the tackle when operated has the spreader in a horizontal position. The lifting should be done as close as possible to the position in which the dismounted body is to be placed, so that, after lifting and running the chassis from under it, the body may then be lowered on to its trestles or body-horse.

Lifting Body with Sliding Roof

If the front chains are apt to rub the sides of the body at the roof, a piece of canvas is wrapped round them. The body may also be lifted in front, if it has a sliding roof, by opening the roof and passing the front chains through the roof opening, as shown in Fig. 10. The spreader if too wide may be discarded and a short length of chain or a piece of rope used to draw the front chains together. The chains should be padded at the roof line so as not to injure the mounting of the sliding roof.

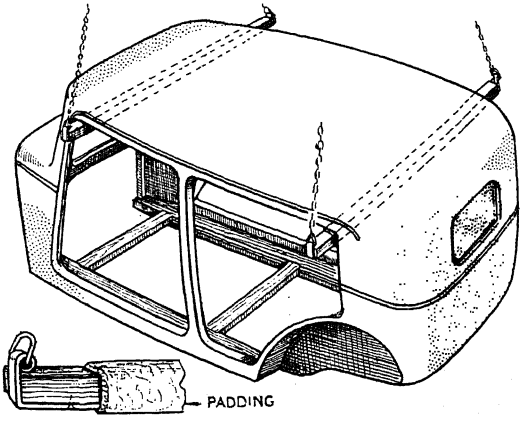


Fig. 14.—THE BARS SHOWN IN FIG. 13 ARE PLATED ON THE UNDERSIDE, PADDED THEIR FULL LENGTH AND FITTED WITH SHACKLES FOR THE ATTACHMENT OF THE LIFTING CHAINS

Fig. 13.—LIFTING A BODY WITH A PAIR OF BARS PLACED UNDER THE ROOF AT THE EXTREME FRONT AND REAR OF THE DOOR OPENINGS

Dismounting Bodies with Folding Heads

A body with a folding head, such as a drop-head coupé, cabriolet, or landaulette, may be lifted with the head closed when it is being lifted from above, as indicated in Figs. 8 and 10, but precautions must be taken by sufficient padding to ensure that the sides of the head are not rubbed by the rear irons, or that there is not any undue side pressure. Otherwise, the head should be folded and again raised when the body has been placed on the trestles.

Lifting at the Roof Level

Another method of lifting a body such as a saloon, but not a body with a folding head, is shown in Fig. 13. In this instance the lifting chains are attached to the ends of a pair of cross-bars $1\frac{1}{2}$ in. wide and 2 in. deep. They are stiffened on the underside with a $1\frac{1}{4}$-in. by $\frac{1}{4}$-in. plate, which is turned at each end, as shown in Fig. 14, so as to form an eye which takes a shackle for the chains. These bars are padded and are inserted in each door opening in the positions shown, that is, close to the front and rear body pillars respectively.

All-steel Bodies

This latter method will have to be used in the case of cars having all-steel bodies, as the light metal sill is generally insufficiently strong to stand the local loads imposed by the chain bolts.

THE MORRIS EIGHT CHASSIS AND BODY

SERIES E

THE SPRING MOUNTINGS

THE spring anchorage in the case of both front and rear springs on the Morris Eight, Series E, is effected by means of rubber bushes, which are provided, on either side, with fibre washers. Should side play develop at these bearings the fibre washers will need renewal.

Screwed-type shackle pins and bushes are fitted to the rear end of the front springs at both ends of the shackle plates, and to the *lower* end of the shackle plates for the rear springs.

Correct Adjustment of Shackles

When refitting the shackles, particularly when new parts are being introduced, it is essential that they be correctly adjusted with equal clearance on both sides. For this purpose Morris Motors supply special gauges under Part No. 67800, two of which are required.

When assembling the components, lubricate the threads of the shackle pin before screwing it into its bush.

Place one of the special gauges on the taper on each side of the screwed pin, and adjust the position of the pin so that each gauge just makes contact with the bush on each side. This ensures that the pin is exactly central.

The gauges are now carefully removed without disturbing the pin, and the felt washers placed on each end of the pins followed by the shackle plates.

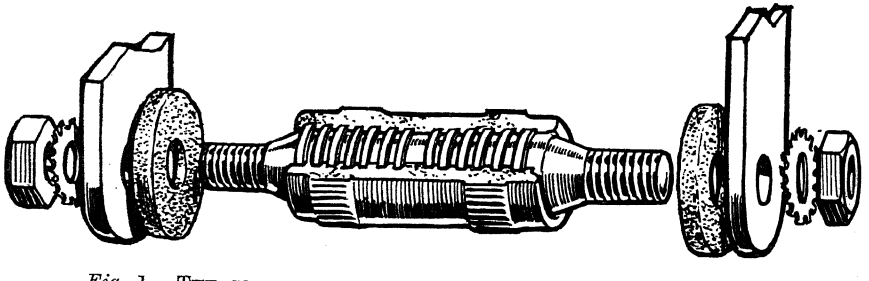


Fig. 1.—THE COMPONENT PARTS OF THE MORRIS SCREWED SHACKLE
Showing their order of assembly. It is essential that the screwed bush is located centrally on the shackle pin.

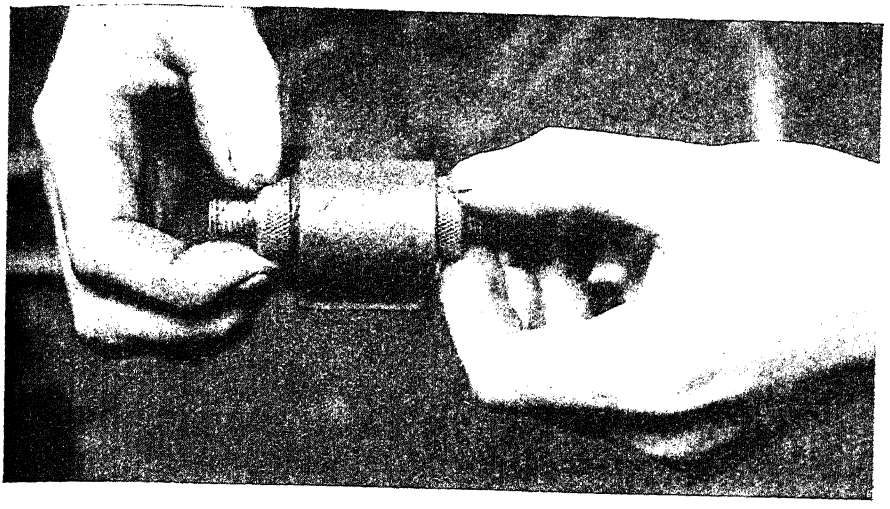


Fig. 2.—ADJUSTING FOR EQUAL DISTANCE ON BOTH SIDES OF SHACKLE

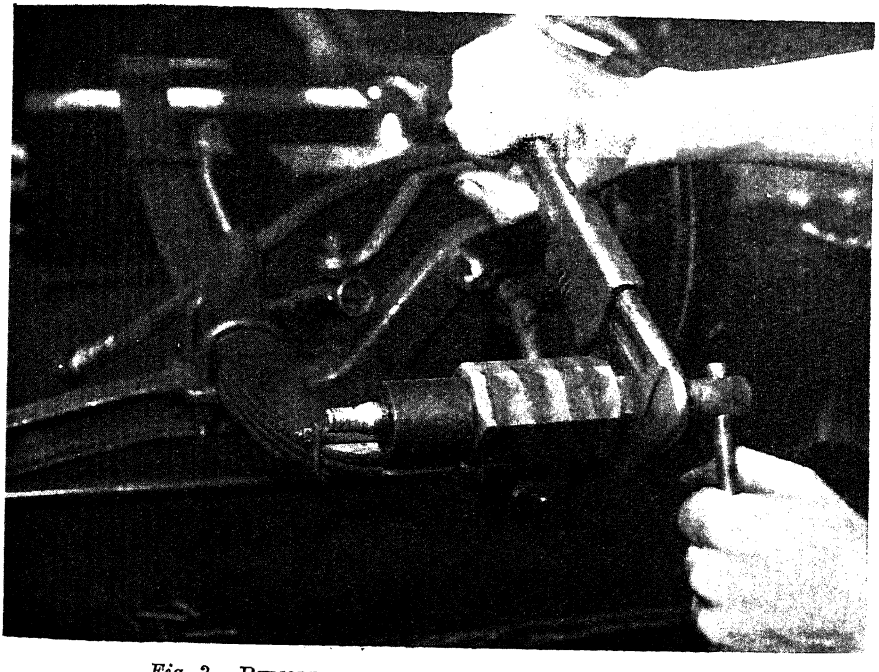


Fig. 3.—REMOVING BUSHES FROM REAR SPRING BRAC

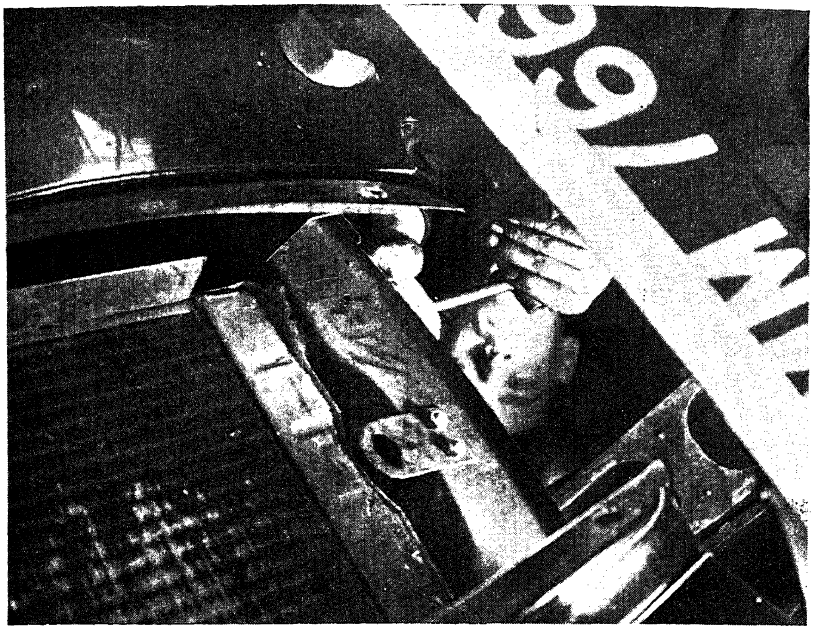


Fig. 3B.—REMOVING RADIATOR

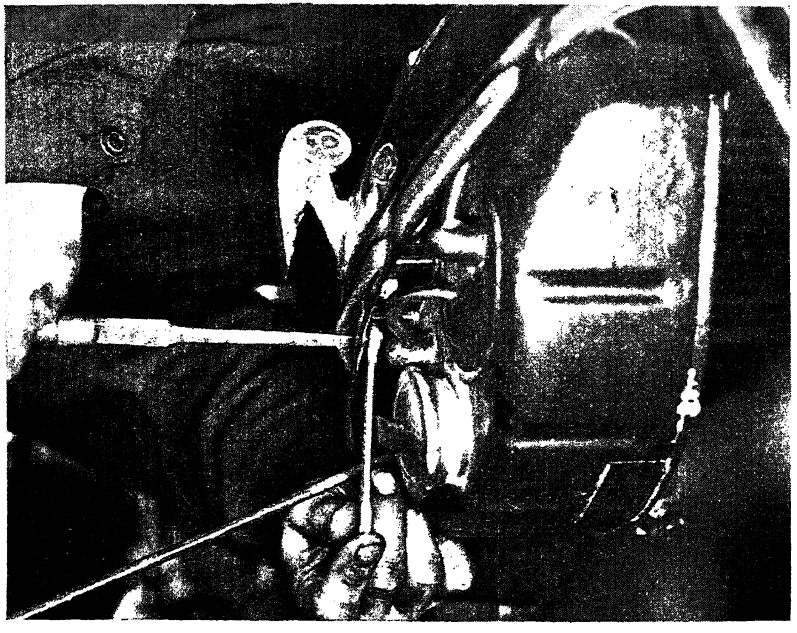


Fig. 3A.—REMOVING RADIATOR SHELL

Pressure should now be applied with a clamp to the sides of the shackle plates, so that they are firmly held in contact with the tapers on the pin. This will prevent rotation of the pin, while the shackle-pin nuts are replaced and tightened up. As an added precaution, see that the shackle-pin nuts turn freely on their threads.

Tighten up the shackle-pin nuts firmly, taking care not to turn the pin itself in the process, and do not forget the shakeproof washers under the shackle-pin nuts.

The upper ends of the rear spring shackles are attached to the frame by a high-tensile bolt supported in two special rubber bushes housed in the spring bracket.

Any new springs supplied by the makers are only fitted with the rubber bush at their anchorage end, so that new screwed bushes should be ordered at the same time if they show signs of wear.

Extraction and Replacement of the Special Bushes

The screwed bushes are pressed into the spring eyes and their extraction and replacement can be carried out with suitable distance-pieces in a press or large vice.

For the special bushes in the rear spring bracket a special tool has been devised by the makers to enable their extraction and replacement to be carried out successfully. This is obtainable from the Service Parts Department of Morris Motors, under Part No. 67849.

To Remove the Steering-column Assembly

First disconnect the battery positive cable by slackening the $\frac{1}{4}$-in. pinch bolt of the terminal lug and withdrawing the lug from the terminal post.

Drain the radiator by means of the drain tap provided in the radiator bottom tank, and release the hose clips of both top and bottom rubber hoses.

Release the hose-pipes from their connections and detach the radiator shell by removing the packing strip from under the bonnet webbing at the top of the shell, undoing the two bolts attaching the radiator shell to the radiator core, and unscrewing the ten setscrews attaching the radiator shell to the front wing valances.

Unscrew the two locknuts and brass nuts from the radiator core attachment studs passing through the chassis front cross-member, and withdraw the radiator core.

Disconnect the four wires leading out of the bottom of the steering-gear box from the special snap connectors provided, and unsolder the nipples from the wire, withdrawing the rubber sheathing.

At the bottom of the steering-gear box will be found a hexagon nut screwed on to the end of the centre tube. Unscrew this nut and carefully ease the protruding portion of the stator tube upwards through the centre tube of the gearbox end cover, taking care not to lose the locking olive. This will enable the stator tube with its trafficator-switch assembly to be withdrawn upwards into the body of the car for some 2 or 3 in.

The cheese-headed clamp-screw which attaches the baseplate of the trafficator-switch assembly to the stator tube is revealed. Slackening the clamp-screw enables the complete assembly with harness cable to be withdrawn.

Push the stator tube back into the steering column, and unscrew the steering-wheel retaining nut with a box spanner. This will enable you to remove the steering wheel with a suitable extractor.

Unscrew the bolts attaching the steering column to the facia-board tray, and release the Bowden-wire control bracket from the steering column, together with the accelerator-pedal bracket assembly.

Raise the offside front wheel clear of the ground and remove the wheel. This will give access to the steering drop arm, which should be released from the steering-gear box shaft, by removing the pinch bolt, and then withdrawn.

The electric horn will also have to be removed by undoing its two attachment bolts.

The two bolts attaching the steering-gear box to the front dumb-iron should now be withdrawn and the steering-gear box side cover should be removed complete with its packing shims and paper gasket, catching the oil released in a suitable receptacle.

This will permit you to extract the rocker shaft from the gearbox, but care must be taken not to lose the felt oil-retaining washer fitted to the rocker shaft on the outside of the gearbox.

The steering column and gearbox assembly can now be pushed into the interior of the car until the steering-gear box is clear of the brake pipe, when it can be lowered between the chassis side member and the engine and withdrawn forward from the underside of the car.

When reassembling, care should be taken to see that the drop arm is correctly replaced on the steering-gear box shaft, with the mark on the rocker shaft coinciding with the mark on the drop arm. Care should also be taken to see that the right number of shims are in position under the steering-gear box side plate when this component is replaced.

REMOVING SALOON BODY FROM CHASSIS

Remove the front seats by releasing the nearside-seat clamps and raising the offside-seat adjuster, and sliding the seat forward until it is clear of the runner.

Remove the rear seat and seat squab, the latter being released by the removal of the three round-headed wood screws, access to which is obtained through the luggage compartment.

Take out all the floor carpets, remembering that the front-seat steady clips must be removed before the rear carpet can be withdrawn. The steady clips are removed by unscrewing the two countersunk screws which are found in each

Disconnecting the Various Cables

Disconnect the battery cables from the battery by slackening the terminal lug pinch bolts and withdrawing the lugs from the terminal posts. Remove the battery by removing the two attachment bolts, noting that they are equipped with double coil-spring washers.

Disconnect the petrol-feed pipe from the petrol pump, and disconnect the petrol pump from the scuttle. Detach the white wire from the insulated terminal of the pump and the black wire from the other terminal, thus allowing the pump to be placed on the top of the engine during subsequent operations.

The ignition coil should be detached from the scuttle by removing its two attachment bolts, noting that the upper one is equipped with a nut and a spring washer, while the lower bolt forms the anchorage for the engine-earthing cable and screws into a clinch nut, being prevented from working loose by a spring washer.

Release the high-tension cable from the central terminal and release also the two white wires from the terminals on the body of the coil marked "S.W.," and the wire coloured brown and white from the terminal marked "C.B."

The junction and control-box unit can be removed from the scuttle by undoing the two round-headed attachment screws, without disturbing the wires connected to it. It should be noted that a rubber washer is fitted to each attachment screw between the base of the control box and the scuttle.

Release the starter cable, together with the battery cable and the yellow and black wire from the starter switch, by undoing the terminal nuts.

Release, also, the two leads from the windscreen-wiper motor, making a note that the green-and-purple wire is attached to the terminal nearest the scuttle. Now pull the two wires through from the inside of the scuttle and release the black wire which is attached to one of the fixing screws for the chassis identification plate.

The Instrument Panel Wires

Remove the instrument panel in the manner indicated in Vol. IV, and release all wires connected to it, making a note of their points of connection for replacement purposes.

The wires concerned, looking at the back of the panel, are :

(1) The yellow wire for the ignition warning light.

(2) The black wire attached to the speedometer support frame.

(3) The white wire attached to the centre terminal of the switch-box.

(4) The blue wire attached to the right-hand bottom terminal of the switch-box.

(5) The black-and-white wire attached to the centre bottom terminal of the switch-box.

(6) The three red wires attached to the left-hand bottom terminal of the switch-box. (Note that the fourth and uppermost terminal at the bottom of the switch-box has no connections.)

(7) The two black wires attached to the instrument attachment frames.

(8) The purple-and-blue wire leading to the upper petrol-gauge terminal.

(9) The purple-and-black wires leading to the lower petrol-gauge terminal.

Now detach the windscreen-wiper blade from its spindle by slackening its locking screw, and withdraw the rubber seal. Release the wiper spindle and switch assembly from its bracket by removing the two round-headed attachment screws, and unsolder the wires from the switch-terminal clips, making a note that the green-and-purple wire is attached to the top and the black wire to the bottom.

The harness cable and speedometer cable can now be withdrawn from the scuttle, from the engine side, after the harness clip has been released from the underside of the tool-box.

Part the two trafficator wires by separating their snap connectors which are to be found under the rear offside floorboard. The protecting cover should be removed from the top side of the floorboard and the ends of the wires should be drawn up into the body.

Disconnect the tail-lamp and stop-lamp wires from the lamp terminals, noting that the purple wire is connected to the stop lamp and the red wire to the tail lamp, while the black earth wire is, of course, attached to the earth-terminal clip.

The bonnet should now be removed by unscrewing the two fixing bolts attaching the bonnet to the hinges, and placed in a position where it will not be damaged.

Tray below Facia-board

The tray below the facia-board should be removed by unscrewing the two bolts from the steering-column steady bracket, removing the fixing screw with raised head from the centre support for the tray, extracting the seven bifurcated rivets attaching the tray floor to the front rail, and unscrewing the setscrew and bolt attaching each end of the front rail to the side of the body. This will enable the tray front rail to be withdrawn after the trimming at each end of the rail has been detached and folded down to clear.

Slacken the locknut of the gear-box knob, unscrew the knob, and then pass the rubber gearbox cover over the lever.

The nearside and offside floorboards are next removed by unscrewing the series of countersunk screws with dished washers, and the foot-operated dipping switch is also removed by unscrewing the two round-headed attachment screws.

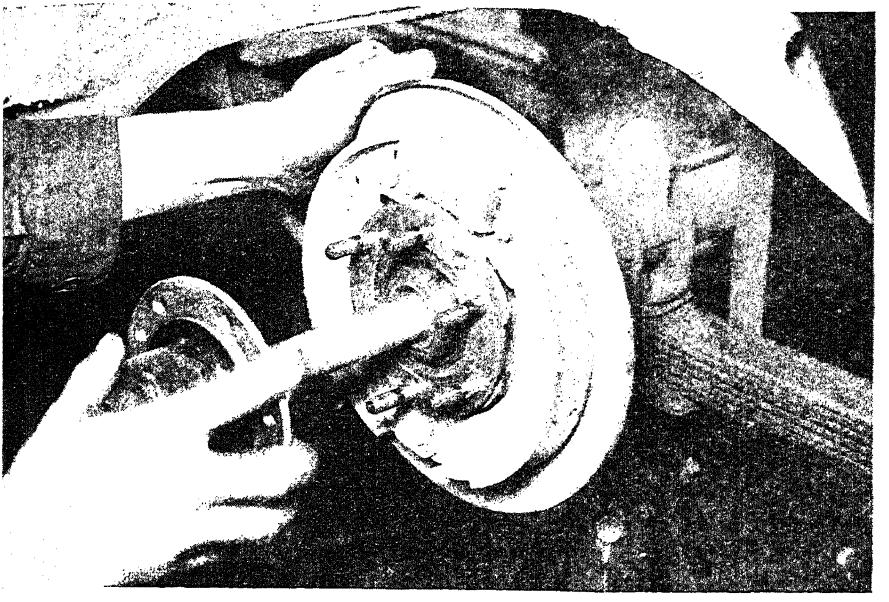


Fig. 4.—REMOVING AXLE SHAFT

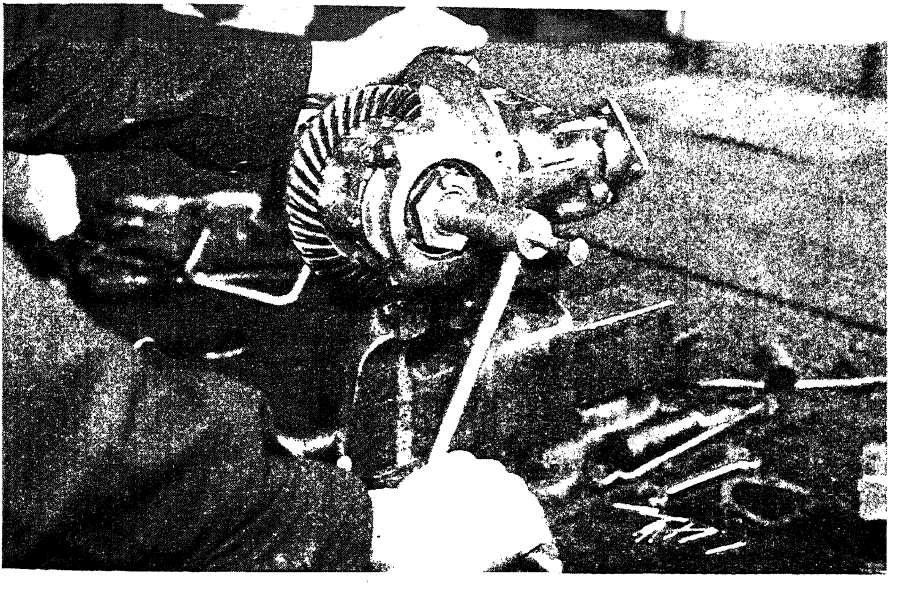


Fig. 5.—ADJUSTING DIFFERENTIAL ASSEMBLY

The Karhyde draught strip should be released from the side of the body.

The offside toe-board may now be released by unscrewing the six countersunk fixing screws with dished washers, and the dipping switch may also be removed by unscrewing the two round-headed attachment screws.

The nearside toe-board, together with the gearbox-shield assembly, can then be detached by unscrewing the six countersunk (with dished washers) and the one round-headed attachment screws.

The opening below the steering column is closed by a small metal plate, which should be detached by undoing the two retaining screws with dished washers.

The three bolts attaching the scuttle side panel to the bonnet valance on each side should now be removed, together with the four bolts which secure the rear portion of the front wings to the body.

The rear bumper bar also needs removal and this is accomplished by releasing the small metal plates covering the bumper-bracket bolt holes on the underside of the wings. These plates have keyhole-type slots which enable them to be removed without completely unscrewing the attachment screws. The bumper-bracket bolts are now exposed and can be unscrewed by means of a box spanner, permitting the withdrawal of the bumper rearwards.

The Body Attachment Screws

Attention should now be given to the body attachment screws, eight of which locate the body to the frame member on each side, and three attach the rear of the body to the rear chassis cross-member. In addition there are eight bolts on each side which attach the lower flange of the body sill and wheelarch to the bottom flange of the chassis side member.

Before removing the body it is necessary to release the petrol-tank filler by slackening the hose clip inside the luggage boot and withdrawing the fillers from the side of the body.

While it is by no means essential to remove the rear wings, it may sometimes be wise to do so in order to avoid damage if the removal of the body is carried out in a restricted place or with meagre equipment.

How to Lift the Body

The body is best removed from the chassis by the help of four men provided with suitable lifting poles which can be passed under the body if the rear end is first raised a short way for the insertion of the rear pole over the centre of the rear wheels, and the front end then raised for the insertion of the forward lifting pole just to the rear of the handbrake-lever bracket.

With one man at each end of the poles the body should be lifted clear of the chassis and walked backwards, taking care to see that the body clears the steering wheel.

Reassembly

Reassembly is carried out in the inverse order to removal, and it is essential to see that the scuttle side panels go right up against the bonnet valances, and to replace the three bolts on each side and tighten them up before making any other attachments.

It is also important to make sure that the electrical connections are correctly remade, remembering that the positive-earth system of wiring is employed.

ROVER REAR AXLES

By F. G. HAWKINS

BEFORE dealing with the question of servicing Rover rear axles, it would be as well if we make ourselves familiar with the various types used from 1934 to 1940. If we ignore minor modifications that have taken place from time to time, the axle assembly can be divided into three main groups, the first of which was fitted to all models from 1934 to the middle of 1937.

Axle Assembly up to 1937

As you will see from Fig. 1, the axleshaft (47) is fitted with a loose hub (50) fitted to a taper shaft, and that the axle and float are controlled by shims (44)—it is most important to remember this because, as will be seen later, it is not always so, and you are asked to notice particularly several other points also because they, too, vary considerably in the next two groups.

On the inner side of the hub assembly a Gitts oil seal (46) is fitted, and on the outer side a cork ring (49) prevents the escape of grease.

The differential consists of a differential case (8) to which the crown-wheel (7) is *riveted*, the whole being mounted on two tapered roller bearings (16), and adjustable locknuts (17) are provided by means of which the correct amount of backlash between the crown-wheel and pinion can be obtained.

Finally, we have two differential wheels (9) carried one on each of the splined inner ends of each axleshaft, and two differential pinions (10) carried on the centre spindle (11). Notice particularly that this centre spindle can be removed without disturbing the crown-wheel, because that point has a great bearing upon the question of the axle service on later models.

The bevel-pinion assembly is carried by two bearings (20) and (23) in the pinion housing (15), the rear of which is carried by two spring clips (21) and is separated from the front bearing by a distance-piece (24). The front bearing is carried in a bearing housing (22), and shims (29) and (30) are used to obtain correct location. The whole is locked up on the pinion shaft (6) by a nut and lock-washer (25) and (26), and the assembly is retained in position by an end cap in which is carried a Gitts oil seal (27) and (28).

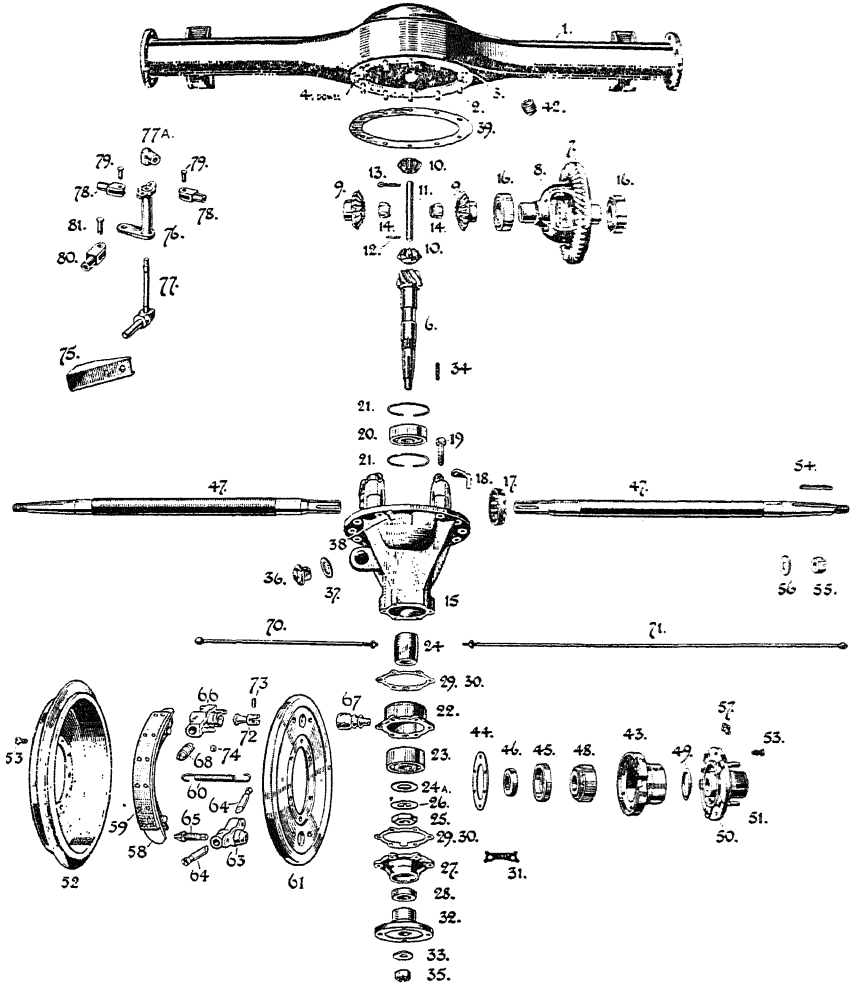


Fig. 1.—AXLE ASSEMBLY FITTED TO ALL MODELS FROM 1934 TO THE MIDDLE OF 1937

Axle Assembly, 1937–9

Now we will examine the second group (Fig. 2). All axles in this group were used from the second half of 1937 on 10-, 12-, and 14-h.p. models, and from the first car on all 16-h.p. and 20-h.p. models.

Apart from a few minor details, the differential and bevel-pinion assemblies are as on previous models, but the axleshaft assembly has been

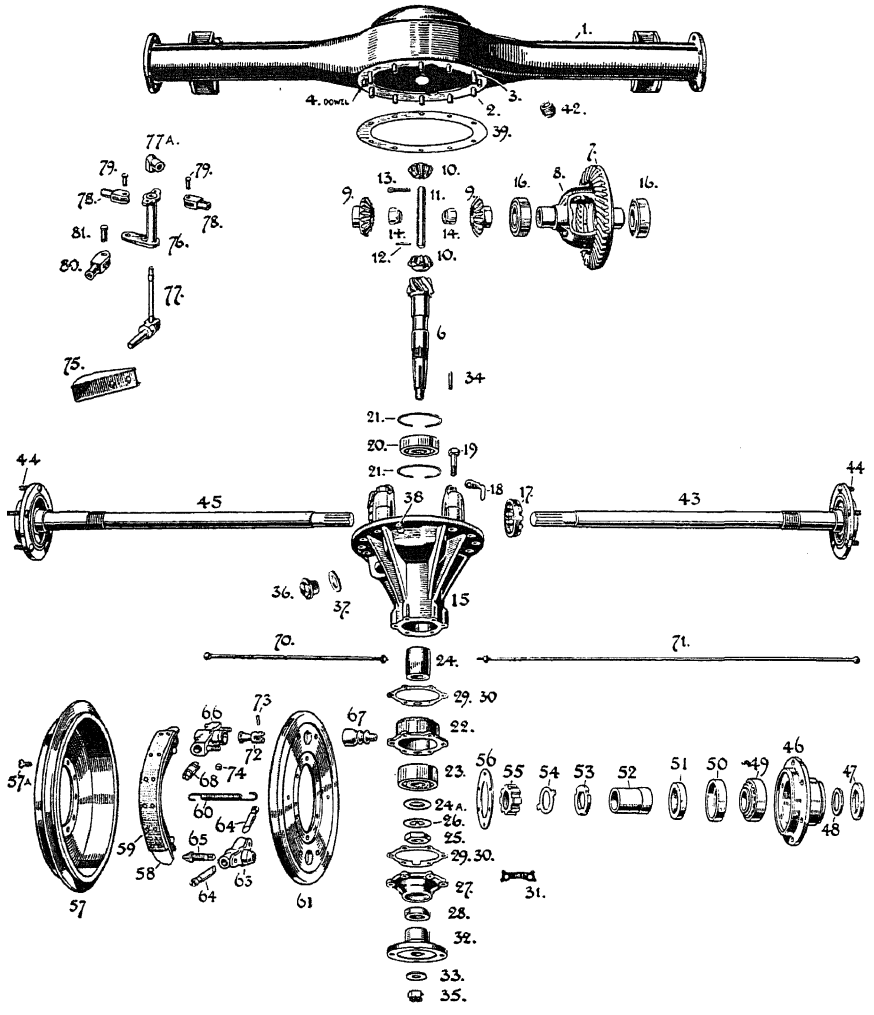


Fig. 2.—AXLE ASSEMBLY USED FROM THE SECOND HALF OF 1937 ON 10-, 12-, AND 14-H.P. MODELS AND FROM THE FIRST CAR ON ALL 16-H.P. AND 20-H.P. MODELS

completely redesigned, the hub no longer being loose but forged in one piece with the axleshaft; therefore the only part of this axle assembly we need to reconsider is the axleshaft.

As was formerly the case, end float is controlled by shims, but the cork ring on the outer end has been replaced by a Gitts oil seal (47), while the inner oil seal has been retained.

Axle Assembly, 1939–40

The third group of axles will be found fitted to all 1939 models with the exception of the first 3,000, and all 1940 models. As you will see by consulting Fig. 3, there are considerable alterations at several points.

First of all take the differential assembly; this is now offset to the extent of $\frac{5}{8}$ in.; the reason for this is to obtain equal loading on both bearings, a state of affairs that did not exist before, and it results in a much quieter axle, but its effects upon servicing methods is considerable. For instance, axleshafts are *no longer* interchangeable between nearside and offside, as was formerly the case, because one is now longer than the other. If it becomes necessary to fit a new shaft at any time, make sure that the correct one has been obtained or much time will be wasted. If the long shaft be fitted to the short side, it will not be possible to bolt it right home and the error will be quickly discovered, but if the short shaft be fitted in place of the long one it will bolt home, but will not drive, and the fact will not be discovered until it is attempted to drive the car.

Dismantling

Another point to remember regarding differential assemblies in this group is the effect the offset crown-wheel has upon the question of dismantling. It will be remembered that groups 1 and 2 had the crown-wheel secured to the differential case by rivets; it has now become necessary to dispense with these and use bolts instead; this is because the position now taken up by the crown-wheel prevents the removal of the differential wheels and pinions until the crown-wheel has been removed in order to clear the centre spindle—hence the use of bolts.

Early types of this assembly use a series of bolts and two dowels, but on later assemblies two fitted bolts take the place of dowels. A word regarding the fitting of a new crown-wheel to the differential box would not be out of place here.

When a crown-wheel is fitted originally by the makers, the series of ordinary bolts are fitted first and then the holes for the fitted bolts are reamed to suit. This method cannot be used when fitting a replacement crown-wheel, for obvious reasons, so fit the fitted bolts first and the ordinary bolts afterwards. The same remarks apply where dowels are used.

In the axleshaft assembly lies the biggest alteration in this group; it will be noticed that the securing nut on the inner end has been dispensed with, the outer oil seal has gone, as have also the shims and thrust-pieces.

Assembly of Axleshafts

The type of axleshaft assembly used in group 1 is too well known to require assembly instructions, so we will deal only with groups 2 and 3.

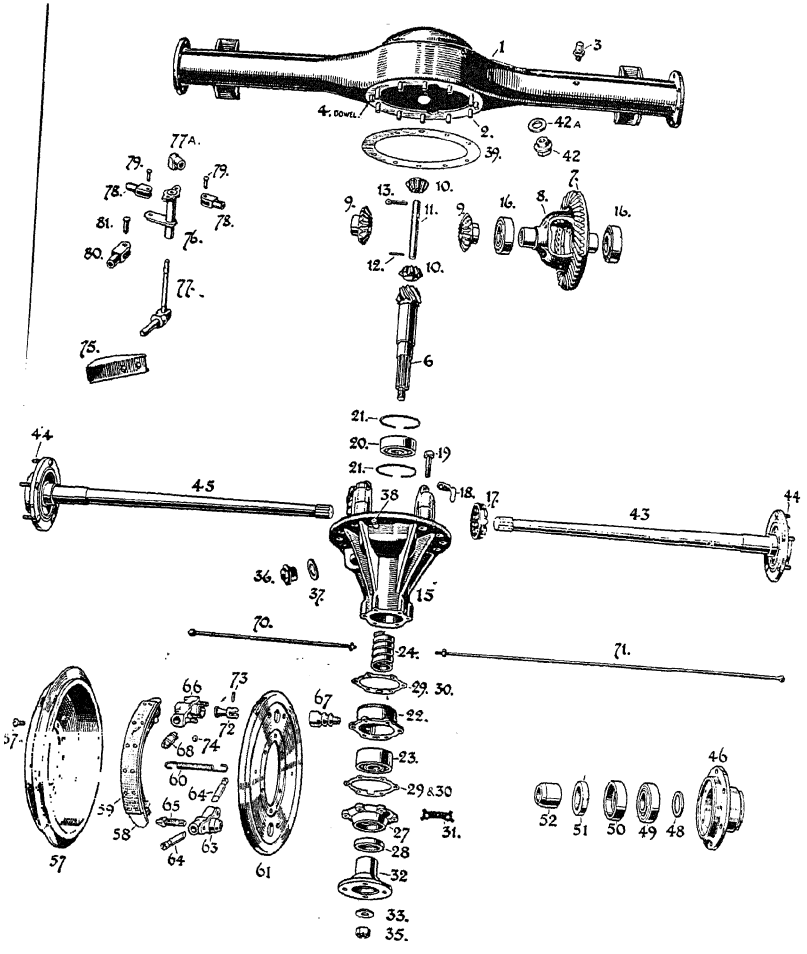


Fig. 3.—AXLE ASSEMBLY FITTED TO SOME 1939 AND ALL 1940 MODELS

Axleshaft Assembly, Group 2

Press taper-race outer ring (49) into housing (46) and fit the oil seal from opposite side (knife edge inwards).

Fit the anchor plate to the housing (six bolts), fit the inner oil seal (50) into housing (51) (knife edge outwards), fit the distance-washer (48) (chamfered edge towards hub) on the axleshaft.

Fill the bearing housing with grease and fit it over the axleshaft. Press the inner race, followed by the sleeve (52), into housing and press

the whole assembly right home. Fit the oil-seal housing (knife edge towards differential). Fit lockring tab washer and locknut.

When fitting the shaft to the axle case, return all shims as originally fitted and then check over for end float. If anything more than bare perceptible float is present, it must be removed by removing shims to suit. It will be found that shims are fitted of varying thicknesses from ·005 to ·064 in., thus enabling this to be done. On the other hand, if the shaft is butting or pinched, there will be a tendency for both shafts to turn in the same direction if one is turned. In that case, add shims as required until a correct balance is found, and a differential action results when one wheel is turned. If too much end float is present a " clonk " will be heard when cornering or when picking up from overrun to drive, and should a complaint of that nature be made the axleshaft end float should be checked and reduced to the smallest amount that can be detected, which will be approximately ·005 in.

On some models in this group, it will be found that two distance-sleeves are fitted, because the axleshaft was modified in such a manner that the threaded portion was moved back several inches.

Axleshaft Assembly, Group 3

This assembly is built up in the same way as in the previous group, but the whole is retained by a sleeve (52), which is a press-fit. A pressure of 2–6 tons is required to do this, so it is of no use attempting to assemble unless the right equipment is available ; by far the best method is to obtain a replacement assembly.

When bolting up the assembly to the axle sleeve the question of end float can be ignored, as the axle ends cannot butt, and as a ball race instead of a roller race is fitted, thrust is taken on the ball race. This is a point that should always be remembered, or much time will be wasted.

Bevel-pinion Assembly

The final alteration to be noted on the third group concerns the bevel-pinion assembly ; as you can see (Fig. 3), the taper on the pinion shaft has given way to splines. A coil spring takes the place of the distance-piece, and the locknut and washers have been dispensed with.

The instructions concerning assembly are as on the old pattern where the retaining nut was used.

Assembling of Bevel Pinion

There should be little difficulty experienced in assembling the bevel pinion if the various illustrations are consulted, but there are one or two points to remember.

First of all on the old type, with the taper-pinion shaft, remember to

lap the propeller-shaft flange to the taper on the pinion shaft, thus ensuring a good fit. If this is not done a " clonk " will develop when taking up the drive, indicating relative movement between the shaft and flange.

Secondly, when fitting the front end bearing remember that two types have been fitted from time to time. The most frequently used is Skefko bearing, and it is of the pre-loaded pattern ; the other is a Hoffmann split bearing, and it will need pre-loading by the manipulation of shims.

Proceed in this way :

Press the bearing (23) into its housing (22), making sure that it goes right home ; then check with the aid of a faceplate and feeler gauges to what extent the bearing stands proud of its housing.

Whatever this measurement may be, select shims to the *same* thickness if the bearing is of the pre-loaded type, or, to the same thickness minus ·002 in. if the bearing requires pre-loading, these shims to be subsequently inserted between the end cap and the bearing-housing flange.

Having dealt with these points, proceed to assemble as follows :

Fit the split-ring (21) into the pinion housing, followed by the outer ring of bearing (20), and the second split-ring. Press the inner ring of bearing (20) on to bevel pinion, followed by the distance-piece (24) or spring, whichever the case may be, and bearing housing (22) already assembled with bearing (23).

On the old pattern, the washer, lock-washer, and nut (25) follow ; see that the nut is really tight, and do not use a second-hand lock-washer.

Enter the assembly from the front end, together with the same quantity of shims between the pinion housing and the bearing housing (22) that were fitted in the first instance.

Now fit the oil seal (28) into cap (27) and bolt them up loosely to the pinion housing, together with the pre-selected shims between.

Finally add flange (32), and lock up securely.

FINAL ADJUSTMENTS

Tooth Markings

There now remains the job of adjusting for correct tooth contact ; this is a highly specialised job. It is dealt with by the manufacturers in a silence room and by a highly experienced man. In a book kept for the purpose he keeps a record of all tooth markings, a perfect example of which would show a marking extending from the toe (inner) end of the tooth, three-fifths of its length towards the heel (outer) end of the tooth, and being equidistant between top and bottom of the tooth.

It must be remembered at this stage that correct tooth contact, together with correct backlash, must be the object of any adjustment, and *not* the degree of noise.

Finally, we will go through the available adjustments to make sure there is no misunderstanding.

Differential Adjustment

There is one adjustment provided for moving the complete differential sideways—this is done by rotating the two large serrated nuts, one either side of the crown-wheel, in the required direction—one serration is equal to ·005 in. more or less backlash between crown-wheel and pinion, and it will at the same time raise or lower the tooth bearings. Once this has been correctly adjusted to give ·007 in. backlash and a tooth bearing equidistant between top and bottom of tooth it should never need altering, *not even to correct noise*, as that fault would not lie there.

Pinion Adjustment

The other adjustment is obtained by manipulation of shims at the tail shaft, and its effect is to move the pinion away from or towards the centre of the crown-wheel. The effect of that movement is to increase the lengthwise tooth bearing—towards the heel if the pinion is moved out, and towards the toe if the pinion is moved in. Again it is emphasised that correct tooth lengthwise bearing of three-fifths the length of the tooth, commencing at the toe, must be maintained, or rapid wear of the crown-wheel teeth will take place at either the toe or heel end, according to which way the error lies.

THE TRIUMPH CHASSIS AND BODY

By H. W. ALLISON

Hubs

HUBS are carried on tapered roller bearings, adjustment of the front ones being effected by removing the wheel, which exposes the hub nut. The split-pin is then withdrawn through the hole in the side of the hub and the nut tightened with a box spanner. The tightening should be done with great care, as it is otherwise easily possible to damage the bearings. The wheel should revolve freely, but at the same time there should be no sideways play.

Adjustment of rear hub bearings is a little more complicated, and in this case the wheel must be taken off and the hub pulled off with a drawer. The bearing housing will then be exposed, and this can be removed by taking out the six bolts attaching it to the axle case. Shims of varying thickness will be found behind the housing, and the removal of one or more of these is necessary to cure end play in the shaft. Adjustment is by trial and error, and after removal of the shim, the hub and wheel must be refitted and tested. Here again, it is important to ensure that there is no tightness.

Brakes

These are the Lockheed hydraulic type, and here it is necessary to deal only with shoe adjustments.

The hexagonal heads of the brake-shoe adjuster cams will be found on the backplates of the drums, and clearance between linings and drums is taken up by turning the heads outwards.

Brake squeal may be due to the shoes canting outwards and rubbing the drum, when the brakes are applied, and the cure for this is to fit an additional or, alternatively, a thicker washer on the brake-shoe steady pin.

A fierce brake is sometimes caused by the lining digging into the drum, and the remedy for this trouble is to " back off " or chamfer for about an inch or so the leading edge of the offending lining.

The hand-brake is cable operated, and acts on the rear wheels only. Adjustment is effected by rotating a wingnut which will be found underneath the car, to the offside of the transmission coupling shaft. Equalising adjustment is provided at the cross-shaft end of each cable.

Frequent lubrication of the exposed joints of the hand-brake mechanism is advised, otherwise rusting and stiffness will result.

Steering

The steering box is not adjustable, neither are the steering joints of recent models.

Steering-column Rake and Length Adjustment

The steering-column rake of all models is adjustable, and except for the very early Gloria models, so is the length.

Rake adjustment is effected by slackening off the bolt which holds the column to the scuttle bracket, likewise the two steering box-chassis frame bracket bolts. The column can now be raised or lowered as desired, and the bolts tightened. The chassis bracket bolts are wired together, and the wire should be refitted when the tightening has been completed.

Alteration of the length of the column can be effected after slackening off the slotted nut at the bottom of the steering-wheel boss, by pulling up or pushing down the wheel, as required.

Rattle in Steering Head

A rattle sometimes develops in the steering head, which is caused by movement of the steering-column control-plate assembly.

The cure is simple, and consists only of tightening the two or, in some cases, three grub-screws, which will be found recessed in the boss of the steering wheel. These screws bite on a plate which forms part of the control assembly, and which is housed in the boss.

Steering Wobble—Causes and Cures

Steering wobble, or wheel "patter," may be due to one or more of a variety of defects, these including inefficient front shock absorbers, flattened front springs, worn front-axle swivel pins and bushes, slackness in steering connections, play in front-wheel hub bearings, or unbalanced front wheels.

Balancing Wheels

A simple method of balancing a wheel is to remove all the grease from one of the front-wheel hubs, push the wheel on the hub splines, and rotate it. If out of balance, the wheel will swing before coming to rest. To correct the balance, weights should be attached to the spokes and, as nearly as possible, to the wheel rim, directly opposite to the heaviest and, therefore, lowest point of the wheel. Strips of lead, the total weight of which equals that of the temporary weights, should then be wrapped round the nipple or rim ends of the spokes, and secured by adhesive tape. A neat job is ensured by attaching the lead to the inner spokes, where they are less noticeable, and painting to match the colour of the wheel.

A trial-and-error method of determining the weight necessary to correct the balance is, of course, necessary, and a correctly balanced wheel will come to rest at any point without any swinging motion.

Side Play in Front-spring Shackles

A click, noticeable when turning on full lock, will be caused by the development of side play in the front-spring shackles, and the cure is to fit shims to the spring pins.

Front-wheel Alignment

Excessive or uneven front-tyre wear is an indication of the necessity for checking the alignment of the front wheels. These should be "toed-in" to a maximum of $\frac{3}{16}$ in. and a minimum of $\frac{1}{8}$ in. Measurement should be taken at the hub height, and between the wheel rims. The track rod is adjustable for length, the ends having right- and left-hand threads, and after slackening off the locknuts, or, in the case of recent models, releasing the pinch bolts, the rod may be rotated to increase or decrease the length.

This note applies also to the drag link, should it ever be found necessary to make an adjustment here.

Removing Front-axle Swivel Pins

Removal of the front-axle swivel pins and phosphor-bronze bushes is effected by removing the swivel-pin cotters, and driving the pins, and then the bushes, out from underneath. The installation of an automatic chassis-lubricating system necessitated the fitting of a screwed plug in each bottom bush from 1938 onwards, and these must be taken out in order to expose the bottom of the pins. These plugs should be filled with grease before refitting.

It is advisable to ream the new bushes after fitting, and the best method is to fit and ream the bottom bushes first, and then do likewise with the top bushes. A reamer piloted by the top bush hole should be used for the bottom bushes, and another piloted by the reamed bottom bushes for the top ones.

It may be found, owing to lubrication having been neglected, that the pins are so badly seized in the axle-pin holes that removal in the manner described above is difficult. If a thorough soaking with penetrating oil fails to help matters, time and trouble will be saved by taking out the axle complete, inverting it, and driving out the pins from the top. In this way considerably more force can be applied to the driver.

Removing Front-axle Assembly

Removal of the axle assembly is comparatively straightforward, the procedure being to raise and support the front of the car on a cradle placed under the engine flywheel housing, disconnect the drag link at the drop-arm end, and the brake and oil pipes at the nearest frame junction. Then the axle shock-absorber arm bolts and lastly the spring "U"-bolt nuts are removed. Two small points are worth noting, the first being

that there may be insufficient room between the frame member and the drop arm to free the drag link. In such cases the drop arm should be moved outwards, after slackening the pinch bolt, just enough to give the necessary clearance. It is not necessary to remove the drop arm altogether, and in fact this should be avoided whenever possible, as the presence of the wing may make refitting difficult. The other point is that flexible brake pipes should be disconnected by unscrewing the adapters, and not by attempting to twist the pipes themselves.

Bleeding of the brake system will, of course, be necessary after reassembling.

Front-axle Dimensions

The following front-axle dimensions are applicable to all models from 1934 onwards, and may be useful:

Camber angle $1\frac{1}{2}°$. Castor angle 3°. Toe-in $\frac{1}{8}$ in. to $\frac{3}{16}$ in.

The king-pin inclination of 1934 and 1935 models is $7\frac{1}{2}°$. This dimension applies also to the early Dolomite, Vitesse, and late Gloria models, but it was altered to $8\frac{1}{2}°$ for the 1938 season and onwards. It should, therefore, be noted that the angle of the pivot-pin holes of a Dolomite-, Vitesse-, or Gloria-type axle beam obtained from the makers will be $8\frac{1}{2}°$ irrespective of what the original may be, except for early Gloria models, which remain unaltered.

It may be noted that all front-axle beams are machined on one side for the cotter-pin nuts, and this side of the axle must face the front.

Spring-shackle Rattle

The development of spring-shackle rattle is usually curable by the fitting of hardened shims, which can be obtained from the manufacturers.

Prior to 1938, a plain phosphor-bronze bush was fitted in the spring eyes, and in cases where rattle is found to be caused by movement of the spring on the bush, the fitting of shims, the internal diameter of which corresponds to the outside diameter of the bush, is recommended. If the bush itself moves sideways on the pin, shims having an inside diameter similar to that of the pin should be used.

Two flanged half-bushes are fitted to the springs of models manufactured since 1937, and with this type shims can, of course, be fitted under the bush flange if the side movement is excessive. Should this movement be allowed to develop sufficiently to allow the links to become damaged, the faces of the spring eyes, of models prior to 1938, should be ground, and the inside link faces filed smooth, otherwise new shims will quickly be destroyed. The latter portion of this recommendation is applicable also to cars fitted with half-bushes.

If the pins themselves are worn, they must, of course, be renewed when the assemblies are being overhauled.

Some cases of spring-bracket rivets working loose have been experi-

enced, and the simplest and most effective remedy is to remove the rivets, enlarge the bracket and chassis frame holes to $\frac{3}{8}$ in. and fit bolts and nuts and locknuts in place of the rivets.

Removing Bodies

All Triumph bodies are hand panelled in aluminium, with the exception that in most cases a steel scuttle panel is fitted.

The following notes on removal and refitting of bodies are intended for the most recent productions, these being a little more complicated so far as details are concerned than the Gloria and other early types. The general procedure is the same for the whole Triumph range back to 1934.

Slide the seats from the runners and remove the runners from the floorboards to which they are screwed. Take out the rear seat, squab, etc.

Lift the front portion of the carpet and pull it free of the control pedals, and of the metal strips running along each side of the car floor. Here it may be noted that the organ-type accelerator control fitted to some models hinges on a bracket bolted to the toe-board. The hinge pin is held by a setscrew which will be found at the base of the pedal. Take off the gear-control gaiter, and then remove the floorboards and the rear foot well, all of which are screwed in position. Note that the control-pedal lever pads must be taken off before it is possible to remove the toe-board. Take off the metal propeller-shaft tunnel.

Remove the petrol-tank filler, leaving the rubber hose attached to the tank, and take up the floor of the luggage compartment.

Pull the pedal-box carpets away and take away the glove tray, pedal-box casings, etc., noting that it is necessary to disconnect the steering column at the pedal-box anchorage, and to lower it, also to remove the pistol-grip-type hand-brake control of current models.

Open the windscreen and take out the screen capping screws, take off the central screen-winder handle, and remove the instrument-panel attachment screws (including the steady-bracket screws if brackets are fitted), and carefully lower the panel complete.

Take out the two bolts and several screws attaching the chassis scuttle dash to the body scuttle extension.

Remove the eight coach bolts holding the body to the frame, three at each side and two at the rear. Take out the four coach bolts attaching the front wings to the pedal box, and the screws holding the running boards to the body. Remove the bolts passing through the rear wings and the rear ends of the running boards. Note that the rear wings may be left attached to the body and that it is not essential to remove the front wings either, although this is advisable. Notes on wing removal are given later.

Disconnect the roof light or lights at the switch end of the wires, and the traffic-indicator wires at the special joints which will be exposed in the vicinity of the body centre pillars, at the bottom, when the floorboards

are removed. Disconnect also the tail-lamp wires and the screen-wiper wires.

Remove the rear bumper complete with its brackets.

Lift off the body, taking care not to damage the covering of the steering wheel while doing so. Tie up the instrument panel to the pedal box, to prevent damage while the body is off.

Remounting Body

Having ensured that the body mounting felt strips are in position, place the body on the chassis, and after lining it up, fix the dash to the scuttle.

It is a generally accepted principle to work from the front end when mounting a body ; therefore, attention should first be given to the front doors. These will need raising, assuming that they require any attention at all, and the object is to obtain an all-round gap or clearance of about $\frac{1}{8}$ in. A trial-by-error method has to be adopted, but, broadly speaking, any raising is done by inserting packing of suitable thickness between the body and chassis frame at the nearest mounting point—in this case the points opposite the body centre pillars. When the front doors hang correctly, both front and centre mounting bolts may be finally tightened down.

Repeat the procedure with the rear doors, and when these are correct, the remainder of the mounting bolts may be tightened, care being taken to ensure that the rear of the body is not pulled down when the bolts passing through to the rear-frame member are tightened. Packing-pieces, used as described above, will, of course, obviate this.

The doors usually need further slight adjustment after road test, and this is done by packing the hinges as found necessary.

The front wings may now be fitted, working, as before, from the front end, i.e. attaching the wing stays first of all. The rear wings should be attached to the body before it is mounted.

REMOVAL OF WINGS

1934 Gloria Models

Disconnect the head- and side-lamp wires. Loosen the headlamp standard pinch bolt, and pull the lamp and standard out. Remove the sidelamp attachment nut from the underside of the wing, which will release the lamp.

Loosen the front cowl by taking out the three fender bolts, take off the front bumper, if one is fitted, and the front number plate.

Remove the two front and one rear-wing stay bolts and the three fender bolts passing through the wing flange and the bonnet board.

The wing of this model is separate from the running board, and if it is desired to remove only the wing, it is now only necessary to remove the

tread-strip stud nuts which pass through the wing, and the fender bolts attaching the wing to the running board.

To take off the running board also, remove the fender bolts which pass through the step irons, the body screws which hold the board to the underside of the body, and the fender bolts at the rear end.

The rear wing is easy to remove, as it is held by six coach bolts, and possibly one or two wood screws. The coach bolts are inserted through the wheel arch from the inside of the body, and before the upholstering is carried out, so that every care should be taken to avoid breaking these when removing the nuts. Use penetrating oil or paraffin if the nuts are very tight. (It may be noted that these instructions apply to all models.)

1935 Models

Remove those lamp stay bolts which pass through the wing, and so far as the head- and side-lamps are concerned, proceed as before, noting in this case, however, that it is not essential to remove the headlamps.

The front shock absorber must be loosened, however, as the wing is held between it and the chassis frame and, in addition, the top front-spring link pin must be removed.

Take out the bolts passing through the wing flange, bonnet board, and chassis frame.

A combined wing and running board is fitted to this model, and the heads of the step-iron bolts are concealed by the running-board tread strips. Two bolts attach the running board to the rear wing.

As will be seen, the moulded rubber tread strips are held by aluminium holders which are bolted through the running boards. The insertion of a screwdriver between the strip and the holder is all that is required to loosen the former, after which it may be pulled out of its holder. The easiest way to refit these strips is to insert the whole of one side and press in the other side, bit by bit, with the aid of a screwdriver or similar tool.

1936 Models

Remove the headlamp brackets and proceed as before. Note in this case that the wing stay and chassis wing stay are bolted together, and that, as previously, one spring link pin must be removed.

The wing is separate from the running board, and the two parts are bolted together with five bolts which also pass through the flange of the chromium-plated moulding fitted to conceal the joint.

The running board is attached to the step irons by means of bolts passing through the latter and through L-shaped pieces welded to the board.

1937 and Later Models

The instructions given above apply also to subsequent models, though there are one or two additional points to note. The Dolomite type

of front wing has an extra stay, which will be found below the pedal box, and which is attached to the chassis stay in a manner similar to that described for the 1936 models.

Four bolts pass through the wing flange and riser iron, and the bolts which fasten the front portion of the wing to the side section of the radiator grille must be removed.

Removal of these wings is simplified if the front-bumper studs are taken out.

Rear wings are fitted with splash guards welded to the wings and screwed to the body structure.

Removing Sliding Roof Panels

Sliding roof panels are easily removed, the method of procedure being as follows:

Remove the headlining covered fillet, after taking off the locking handle which is attached by a centre screw. Removal of the fillet exposes the roof lock attachment screws, and when these have been taken out, the panel can be pulled off the runners, over the canopy panel.

The fillet is attached by "invisible" pins.

Water leaks through Windows

A leakage of water via the rear windows indicates the necessity of rebedding these glasses, and after removing the screwed cappings, a thin knife-blade inserted between the bedding rubber and glass is all that is necessary to release the windows, which are, of course, fitted from inside the body.

A bedding compound should be applied generously to the rubbers and the glasses pressed back in position. Surplus bedding compound, squeezed out between rubber and glass, should be wiped off after the refitting of the windows is completed.

A good bedding compound, in addition to being waterproof, will retain a certain amount of resilience, which is a desirable feature.

The moulded rubber window surrounds are attached by means of tacks.

Curing Door Rattles

A general tightening up of hinges, etc., and possibly the fitting of new rubber buffers, will cure door rattles where recent productions are concerned, but the earlier Gloria models have metal wedges screwed to the door frames above and below the doors. Corresponding wedges are fastened to the doors themselves, the top ones being a spring-loaded type. If it is found possible to slide a cigarette card or something of the sort between the top wedges, the fixed wedge on the top of the door frame should be removed, and refitted with suitable packing behind it.

Door Casings and Window Winders

To obtain access to the window-lifting mechanisms, the winder handles and the door casings must first be removed.

The 1934 Gloria type of winder handle is held on its shaft by a spring, and to remove it, a stiff wire, such as a wheel spoke, should be inserted in the hole which will be seen in the flange. Pressure on the end of the spoke will release the spring, and at the same time the handle can be pulled free.

Later-type handles are pegged to the shafts, and to remove these the spring-loaded cover must be pulled back, which action will expose the peg. The driving out of the peg will release the handle.

The " quick-lift " types fitted to Roadster and Royal models have screwed-on handles.

Removal of the door casings of the earlier models requires no explanation, as these are simply screwed to the door structure, but the casings of the more recent productions are attached by means of blocks, and to release these it is necessary to take out the screws which will be found in the door edges.

The chromium-plated door and scuttle mouldings slide over screws fixed in the panels, and may be tapped on and off in a horizontal direction. Bonnet and quarter mouldings are bolted through the respective panels, and in the case of the latter some of the interior trimming must be removed to obtain access to the bolts.

THE A.E.C. CHASSIS

REAR AXLES

THE following notes refer to A.E.C. rear axles, which are all of the fully floating type. Three types of drive are employed :

(*a*) Overhead worm drive.
(*b*) Underslung worm drive.
(*c*) The double-reduction type.

The first part of the article deals with the drives (*a*) and (*b*). Axles of all types have the brake drums mounted on the outside of the hubs so that the brake shoes can be inspected and relined without disturbing the wheel bearings or removing the hubs.

The hubs are mounted on two large-diameter roller bearings, the outer one of which is arranged to take end thrust.

The hub bearings are lubricated with grease, and provision is made to keep the lubricant from the brake shoes by means of a packless gland in conjunction with a felt washer. This gland is shown in Fig. 1, and takes the form of a bronze ring held against the outer rod of the roller bearing by means of a spring.

To remove the Axle from the Chassis

Disconnect the rear cardan-shaft coupling flange, and the brake rods. Remove the wheels, remove the clamping bolts from the inner ends of

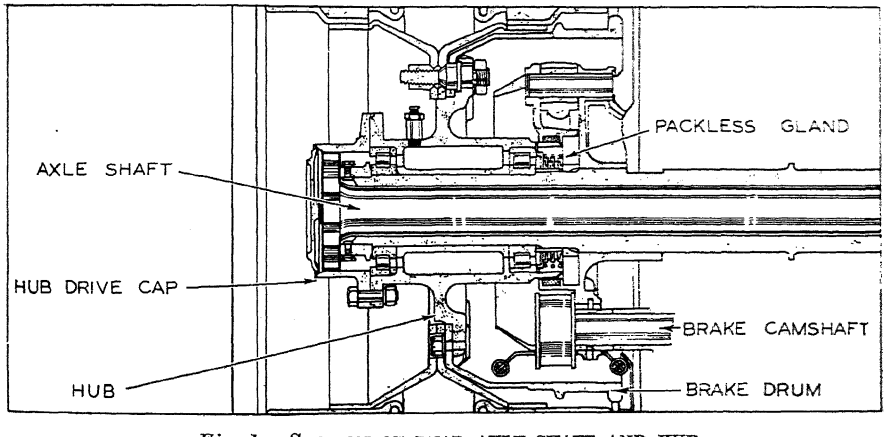


Fig. 1.—SECTION OF REAR AXLE SHAFT AND HUB

the shackle pins, and drive out the pins. Drop the axle on to the ground, jack up the frame until high enough to allow the axle to be drawn out towards the nearside. If available, one of those flat trolleys with only a few inches of overall height will greatly assist in moving out the axle. A piece of board will prevent the nuts on the spring bolts from digging into the ground.

The propeller shaft must not be allowed to hang loose. Wire the shaft up to a convenient cross-member.

To withdraw Axle Shafts

Remove the hub caps and withdraw the axle shaft from the casing.

To remove Brake Drums

Remove the wheels and the slotted nuts securing the brake drum to the hub. Insert two $\frac{1}{2}$-in. B.S.F. setscrews into the withdrawal holes in the brake drums and remove the drum.

To remove Hubs

Remove the wheels, hub cap, and driving shaft. Remove the two locking bolts on the axle-tube nut after first marking the nut and casing to ensure that, when replacing, the nut is tightened up to the same mark. Unscrew the nut and withdraw the hub complete with bearings, distance-piece, and brake drum. The packless gland will be left on the axle tube and can now be removed ; the felt washer will be left exposed in the brake-carrier plate.

Great care should be taken in handling the packless gland so that the rubbing face is in no way damaged. When replacing the hub, the rubbing face of the gland should be smeared with grease to effect lubrication until the oil has a chance to reach this face.

To remove Worm Carrier

Remove the hub caps and axle shafts. Disconnect the rear coupling flange and wire up the propeller shaft to a convenient cross-member. Remove the nuts holding the worm carrier to the axle, screw into the tapped holes in the flange of the worm carrier the four $\frac{1}{2}$-in. B.S.F. set-screws provided in the tool-kit, and force the carrier out of the register in the axle by screwing the four screws up evenly.

Care must be taken that the worm carrier does not fall to the ground.

To adjust the Differential Roller Bearing

The roller bearings carrying the differential are adjusted in the case of the overhead worm drive by means of two slotted nuts which embrace the ends of the bearing cups, or, in the case of the underslung worm drive, by means of shims placed between the bearing and the casing. To obtain the correct adjustment, the two nuts should be screwed up carefully until

the bearings are just nipped, and the nuts then backed off just enough to free the bearings. An end play of not more than ·004 in. should be allowed.

Running adjustment should always be made on the offside bearing, as any slack which has developed will be in this bearing.

For adjusting the bearings when reassembling after stripping the worm carrier, see "Adjusting the Wormwheel."

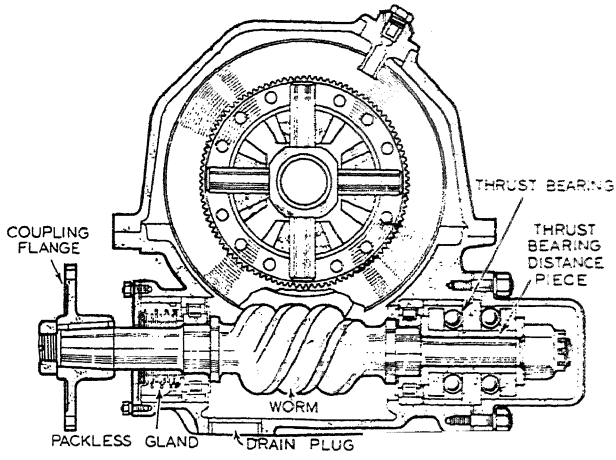


Fig. 2.—UNDERSLUNG REAR AXLE WORM DRIVE

To remove Wormwheel and Differential

Remove the two bearing caps, and lift out the wheel and differential complete.

When replacing the wormwheel, in order that the thrust shall not come on the bolts, the flanged side of the wheel must face towards the near side of the chassis.

To remove Worm

Remove the wormwheel as given previously.

Remove the domed cover from over the thrust bearing, mark the slot in which the split-pin rests, unscrew the nut securing the thrust bearing, and thread the bearing off.

After removing the nuts securing the gland to the front of the housing, the worm may be withdrawn with the forward roller bearing and the gland box in position on the shaft. In the case of the underslung worm drive, a packless gland, similar to that fitted in the hubs, is fitted to the worm shaft.

Except to replace or change the worm, to renew the forward roller bearing, or repack the gland, the Spicer coupling flange should never be disturbed.

It is important that the thrust-race and its distance piece be kept together. If the thrust bearing is renewed, the packing piece must be renewed also. The length of the packing piece must be exact, so as to give the correct amount of end play to the worm. Packing pieces are selected at the factory to the correct length to give an end play of

·006–·008 in. When replacing the nut make certain of the clearance. Over-tightening the nut will compress the distance piece.

To dismantle the Differential

Unless it is absolutely necessary, do not disturb the differential. Otherwise, proceed as follows :

Mark the wheel and differential casing so that the same mesh of the tooth drive can be picked up when reassembling.

The tooth drive between the differential and the wormwheel is made a tight fit, and a considerable amount of pressure will be required to separate them. After removing the bolts, the assembly should be placed on a press with the toothed side downwards. Pack up the wormwheel until the differential casing is about $1\frac{1}{2}$ in. clear of the table and, after placing a piece of soft metal over the upper end of the differential housing, force the housing out of the wormwheel.

The bushes for the differential bevel wheels are made a free floating fit to equalise the drive to all four pinions. The correct clearance, between both the bush and the casing and the bush and the bevel, is ·008 in.

Should a press be not available, a large drawing dog or " Jim Crow " bender can be adapted to the purpose. Great care must, however, be taken to avoid damage to the wormwheel teeth.

If a heavy hammer is used, the greatest care must be taken ; to keep on hammering with a hammer which is not heavy enough to produce any effect will only result in damage to the end of the differential casing.

For reassembling, a press should be employed or, failing this, some bolts procured which are about an inch longer than the bolts used for holding the wormwheel and differential casing together. The casing can then be drawn into the wheel by using a long spanner and working from one bolt to the one opposite until the casing is home. The nuts must be hammered up hard and must on no account be slackened off to enable the split-pin to be entered.

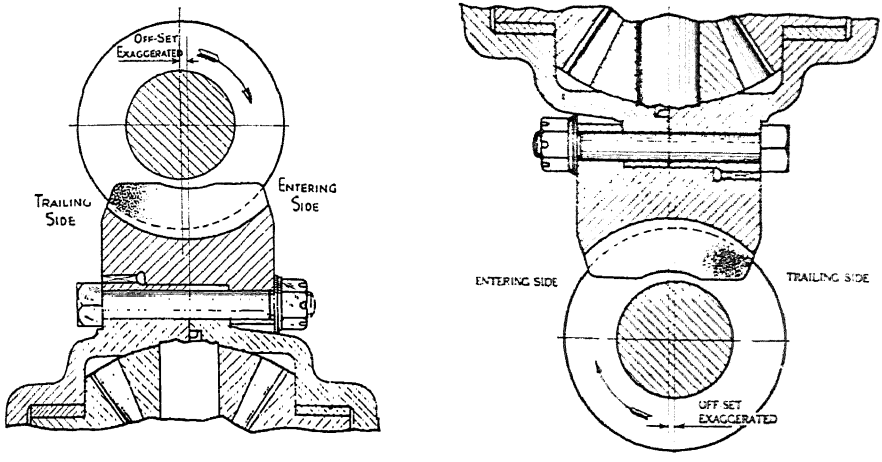
To adjust Wormwheel

Wipe all the oil from inside the worm carrier and give the worm a light coating of blue marking.

Place the wormwheel and differential in position, and replace the caps with the nuts just tightened enough to hold the bearing cups snugly on to their seats.

Dealing with the overhead type of worm drive, by means of the adjusting nuts, bring the worm as central as possible, and, after adjusting the bearings until all the slack is out of them, slack off each nut one slot.

Turn the driving flange of the worm in a clockwise direction and, at the same time, apply a load to the wheel in order to obtain a good marking of the bed on the wheel teeth.



Overhead drive

Underslung drive

Fig. 3.—SETTING OF WORM AND WORMWHEEL

In order to obtain maximum efficiency from worms and wheels, the initial setting of the wheel should be such that the assembly marking (red lead or Prussian blue) is more pronounced on the trailing side of the wheel teeth (as shown shaded) than on the entering side.

Adjust the wormwheel to right or left as required (being careful to turn each nut an equal amount in the same direction), until a marking is obtained which covers from one-half to three-quarters of the width of the tooth, and is *mainly on the leaving side* of the tooth and upon the driving face of the teeth. When running under load, the wheel will be forced over slightly, and the marking will shift towards the entering side of the wheel.

For adjusting the underslung type of drive, shim up until the required marking, as described above, is obtained.

DOUBLE-REDUCTION-TYPE REAR AXLE

In the double-reduction-type driving axle, the first reduction is by a spiral bevel assembly, the second reduction by a double helical pinion and wheel. The axle is fully floating, the hubs being mounted on roller bearings mounted on the one-piece axle pot.

In addition to the foregoing instructions for the withdrawal of axle shafts, and the removal of brake drums and hubs (and exclusive, of course, of those instructions relating to the removal and dismantling of the worm carrier, etc.), the following directions apply to A.E.C. double-reduction-type rear axles.

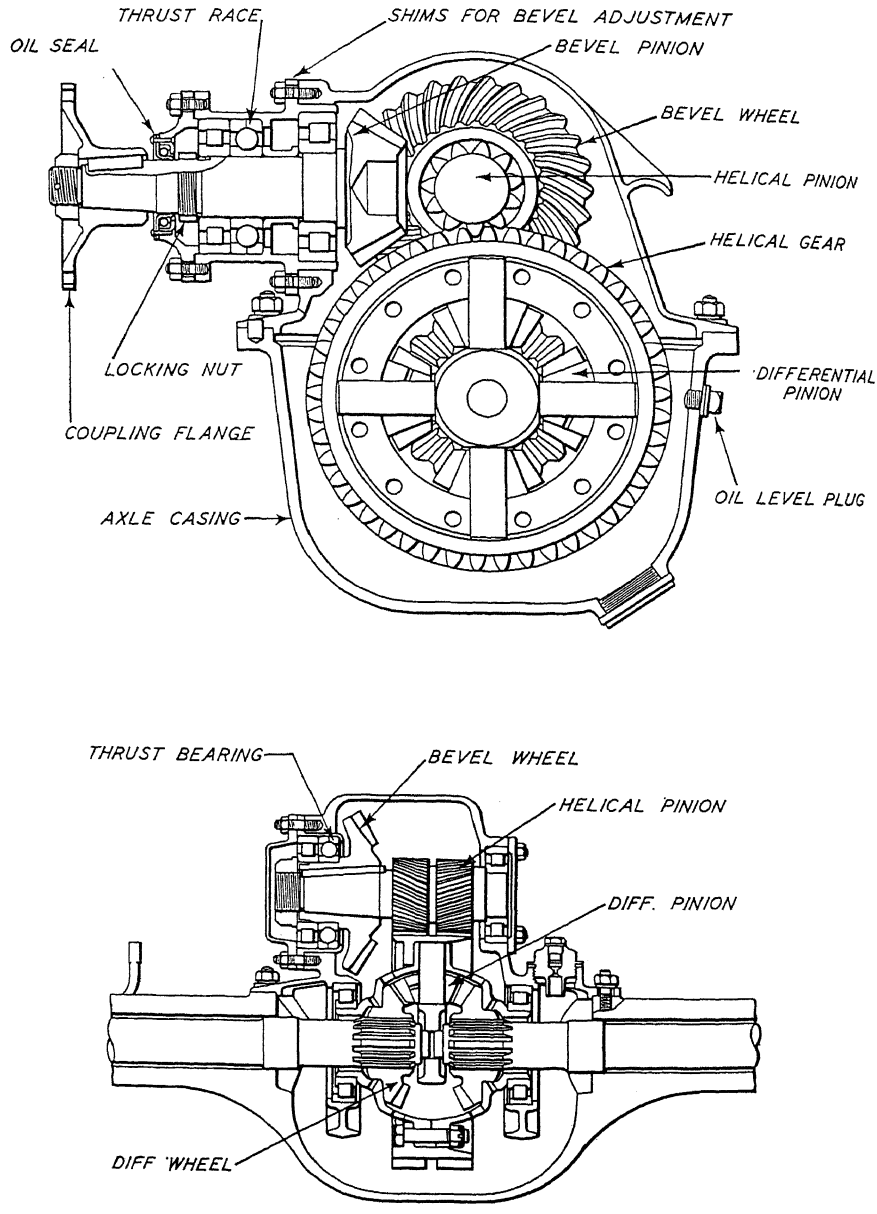


Fig. 4.—DOUBLE REDUCTION DRIVING AXLE

To remove Bevel Casing

The bevel casing can be removed without removing the axle from the chassis.

Remove the hub caps and axle shafts. Disconnect the rear propeller shaft flange. Remove the nuts holding the worm carrier to the axle, screw into the tapped holes in the flange of the housing the four $\frac{1}{2}$-in. B.S.F. setscrews provided in the tool-kit, and force the carrier out of the register in the axle by screwing the four setscrews up evenly.

To remove Double Helical Gear and Differential

Remove the two bearing caps, and lift out the wheel and differential complete.

To remove Bevel Pinion

Remove the nuts from round the flange securing the bearing housing to the reduction casing, and withdraw bevel pinion complete with bearings, housing, and coupling flange from the reduction casing.

To remove Bevel Wheel and Helical Pinion

Remove both the covers from the sides of the reduction casing and unscrew the nut which locks up the roller and thrust bearings, and remove the housing complete with bearings.

In order to remove the helical pinion and shaft, the bevel wheel must first be removed from the shaft. This bevel wheel is mounted on a long taper and the hub of the bevel wheel is screwed so that a withdrawal tool, supplied in the tool-kit, can be screwed on to the wheel.

The only reason for the removal of the wheel from the shaft is when replacement of either of these parts becomes necessary.

To adjust Mesh of Bevel Wheels

Shims are fitted under the housing for the bevel-pinion bearings, and also under the housing carrying the helical gear bearings. Adjustment should be such that the bevel pinion can be freely rotated without any hard spots, and with from ·002 to ·004-in. backlash in the gears. The gears should be so adjusted that contact is made across the whole length of the tooth.

To dismantle the Differential

Unless this is absolutely necessary, do not disturb the differential.

Mark the helical wheel and the two halves of the differential casing so that they may be reassembled correctly.

After removing the bolts, the helical wheel should be pressed off the casing and the casing divided.

FRONT AXLES

The axle beam, steering swivels, and hubs are all of heavy-design forged alloy steel.

The swivels have plain bearings, a roller thrust washer being fitted to take the thrust load. The thrust washer has a spherical seating to ensure uniformity of distribution of the load, and is encased in a pressed steel housing to exclude mud and water. The upper and lower ends of the king-pins are made oil- and water-tight by felt washers.

Two large tapered roller bearings carry the wheel load. The adjusting nut is split, and fitted with a clamping bolt to ensure that it is a tight fit on the thread, and is locked by a setscrew which engages in one of a row of holes drilled in a heavy washer keyed to the stub axle. The nut on the nearside has a left-hand thread, and that on the offside a right-hand thread.

To retain the grease in the hub the usual felt packing is fitted.

To exclude grease from the brakes, a light pressed cylinder is attached to the brake carrier and embraces the inner end of the hub. Attached to the hub is a conical sleeve which overlaps the cylinder on the brake carrier, so that any grease which escapes from the hub will be passed by the cylinder into the cone from which it escapes through holes in the hub to the outside of the wheel, and is thus kept away from the brakes. The appearance of grease at the openings in the hub serves as an indication that either too much grease is being fed into the hub or that the felt needs replacing.

The swivels are fitted with an adjustable stop to limit the travel. These are adjusted correctly at the factory and should need no further adjustment unless larger tyres are fitted at any time.

Maintenance

The front hubs must be kept full of grease. If the hub is not filled right up, the grease will not reach the thrust end of the inner bearing, which will consequently wear on the ends of the rollers. Adding a small amount of grease to a bearing which is not full will only displace some of the air and will not force the grease to all parts of the bearing.

The spring bolts must be kept screwed up hard and checked every 5,000 miles. The king-pin must be lubricated with oil.

Every 5,000 miles check the bearing adjustment, and readjustment if more than a just perceptible amount of shake can be felt.

At the same time the alignment of the wheels must be checked. The front wheels must be kept between parallel and $\frac{1}{8}$-in. toe-in, and must be adjusted at once if found to be otherwise. The ends of the track rod are screwed right- and left-hand to facilitate adjustment.

To remove the Axle as a Unit

Jack up the frame to take the weight off the springs. Disconnect the Lockheed-brake flexible pipe, shock-absorber links, and the drag link.

The latter is done by removing the nut which holds the ball stud to the steering arm, and driving out the ball stud.

Remove the clamping bolts holding the springs to the axle and roll the axle from beneath the chassis.

To remove the Hubs

Remove the wheel and hub cap, take out the locking screw, slack off the clamping screw, unscrew the nut, and pull off the hub. The inner races are a push fit on the stub axles, and that of the inner bearing will probably remain on the axle, but the outer bearing will come away complete with the hub.

The axle must not be allowed to rest on the dust shields, but must be packed up so that the shields are clear of the ground.

If the felt washer requires renewal, the bearings must be adjusted before the washer is placed in position. After adjusting the bearings, the nut and the lock washer must be marked. The hub must then be removed and the new washer fitted, and, after replacing the hub, the nut must be brought up again to the same position with the lockscrew in the same hole of the lock washer.

Unless this precaution is adopted it is difficult to be sure of the adjustment, as the compression of the felt washer makes it difficult to check the amount of slack in the bearings.

After replacing the wheel, always check the bearings for slack: the greater leverage given by the wheel makes it easier to feel any clearance. The bearings must be adjusted to give a just perceptible amount of shake when throwing the whole weight of the body on the wheel.

The hubs must not be interchanged, as the wheel studs are right-hand on the offside and left-hand on the nearside.

To remove the Swivels

Remove the wheel and hub. Remove the front-wheel piston, etc., as described later under "Brakes"; also remove the bleeder screw and adapter from the top of the king-pin.

Slacken off the nut at the top end of the king-pin until the surface of the nut is somewhat above that of the end of the pin, and free the pin from the axle with a sharp blow from a heavy *soft* hammer.

The king-pin should be a good fit in the bushes, but should also be quite free. Should the clearance exceed ·03 in., the bushes should be replaced.

The swivel should be free, without end play. This is governed by the plain washer fitted on the top of the axle boss, this washer being selected to be a push-fit into the space between the axle and the swivel. This washer, however, takes no load, as all the thrust comes on to the roller washer beneath the axle boss.

The pressed steel housing to the roller washer must be free in the

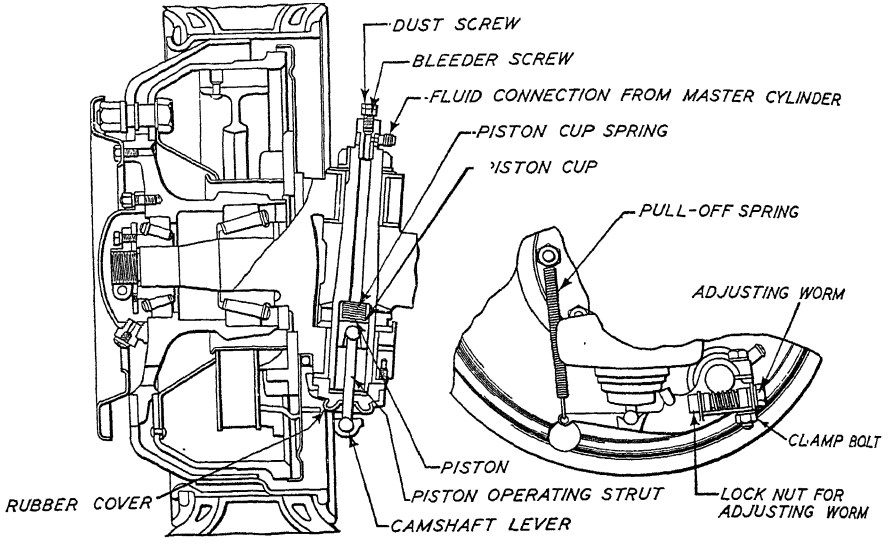


Fig. 5.—ARRANGEMENT OF FRONT AXLE AND FRONT BRAKE CYLINDER

recess in the swivel, and should remain stationary when the swivel is moved. While the swivel is dismantled the roller washer and its recess should be thoroughly washed out to remove any grit or rust which may have accumulated. A thrust washer which shows any signs of wear or indentation should never be used again. When replacing the washer it should be well packed with grease.

If, for any reason whatever, the Lockheed pipes are disconnected, the whole system must be bled. It is important, too, that before the wheel piston and cups are reassembled, they be thoroughly cleaned with Lockheed Orange-fluid.

BRAKES

The foot-brake operates on all wheels and is actuated by a servo-assisted Lockheed hydraulic system. The hand-brake operates on the rear wheels, and actuates the same set of shoes as used for the foot-brake.

The brake drums are 17 in. in diameter, and the shoes are 6 in. wide on the rear and $3\frac{1}{4}$ in. wide on the front. All the brake shoes are fitted with $\frac{3}{4}$-in. thick liners, and provision is made for packing-plates to be inserted between the cam and the rubbing-plate so that the liners may be worn down to the minimum thickness before relining. The application of these rubbing-plates is shown in Fig. 8.

Various arrangements of brake gear are shown in Figs. 6, 7, and 9.

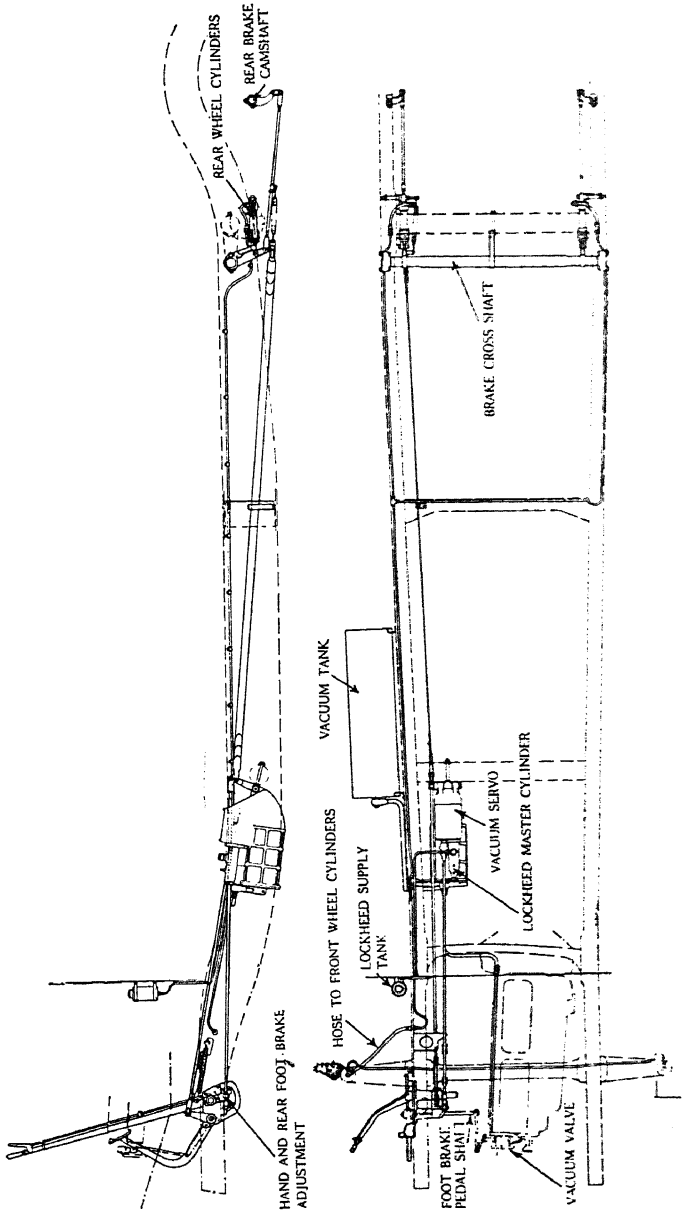


Fig. 6. BRAKE LAYOUT

Showing combined Lockheed master cylinder and vacuum servo.

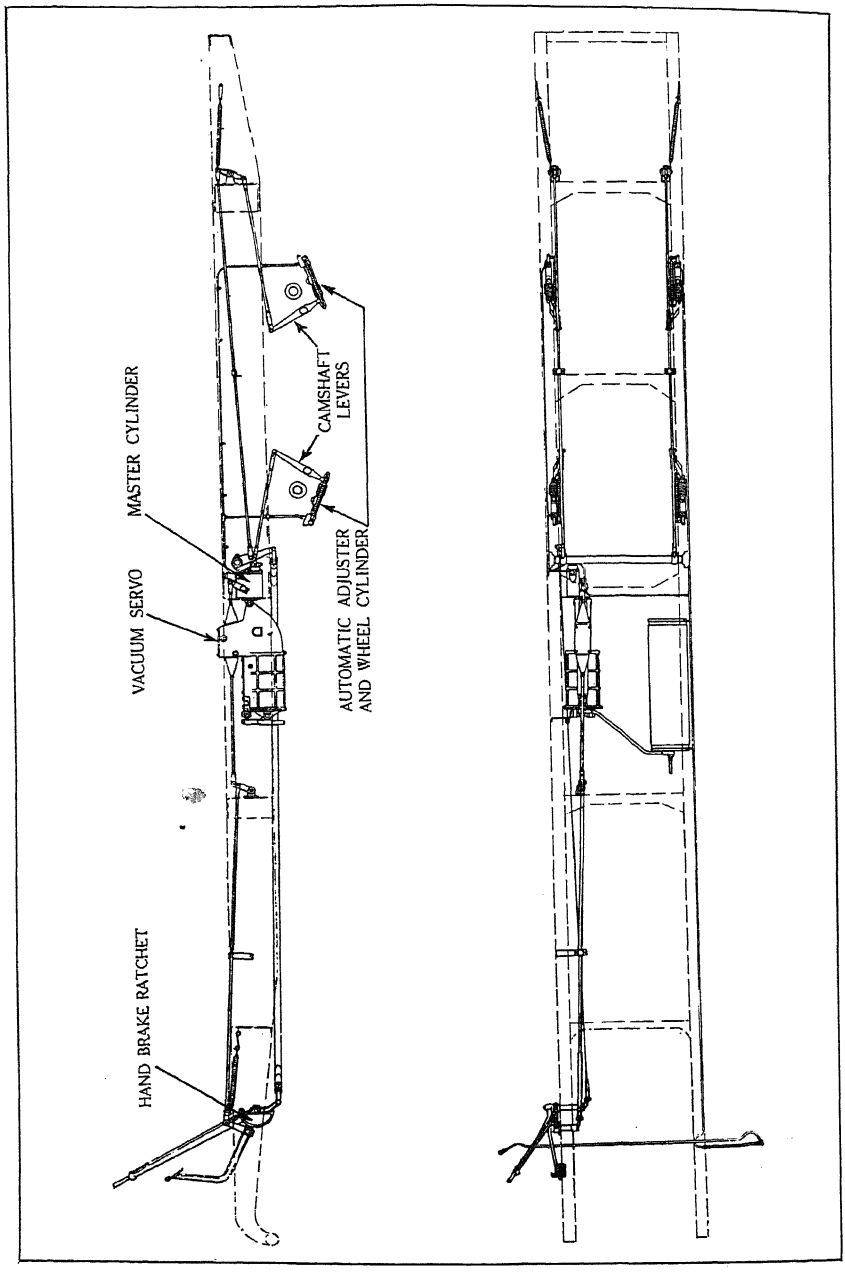


Fig. 7.—SIX-WHEELER BRAKE LAYOUT
Note the automatic brake adjusters for the rear four wheels.

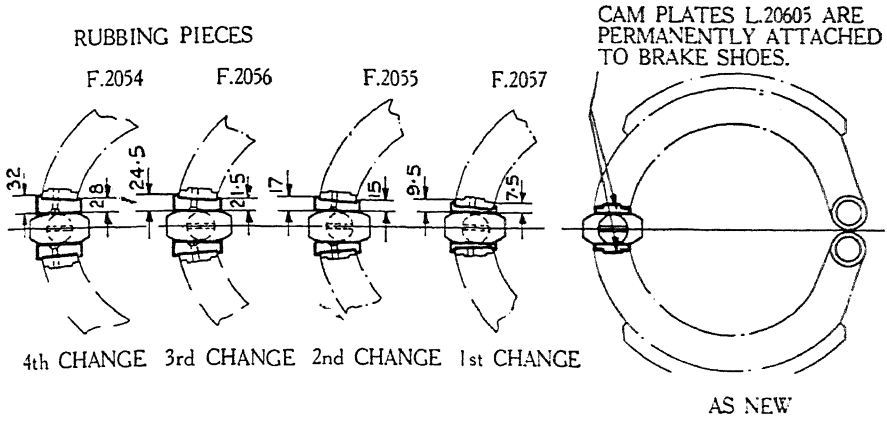


Fig. 8.—FITTING BRAKE-SHOE RUBBING PLATES

Note.—An additional rubbing piece should be fitted when the angularity of the cam, as determined by line machined on end of camshafts, is from 40° to 45°. F.2055 being normally suitable, F.2057 to be used if it is desired to pack brakes before an angle of 45° is reached. To fit additional rubbing piece, force shoes apart and insert piece required. Additional pieces are retained by peg locating in standard cam plate.

Front-wheel Cylinders

The front-axle king-pins are bored out at their bottom ends and form the cylinders in which the pistons work. the actuating fluid being admitted at the top of the king-pin (*see* Fig. 5).

Fluid pressure is transmitted through the piston to a short ball-ended strut, the lower end of which rests in a cavity in the cam lever. Round the lower end of the cylinder a rubber boot is fitted which prevents dust and water from affecting the working parts.

Brake Adjustment

The length of the brake rod between the servo and the master cylinder is set at the factory, and should on no account be altered. Shortening of this rod will result in binding brakes.

Rear Brakes

The rear brakes on some chassis are adjusted by means of the adjusting nuts on the rear-brake camshaft levers. As it is obviously impossible to provide sufficient adjustment to completely wear out the extremely thick liners fitted on the brake shoes, it is necessary to insert packing between the brake shoes and the camshaft when the rear-camshaft levers come too far over centre. The procedure to be adopted when this is necessary is explained in Fig. 8.

Automatic Adjusters

In other chassis, the rear-brake adjustment is automatic. There are two types of automatic adjuster used in A.E.C. chassis.

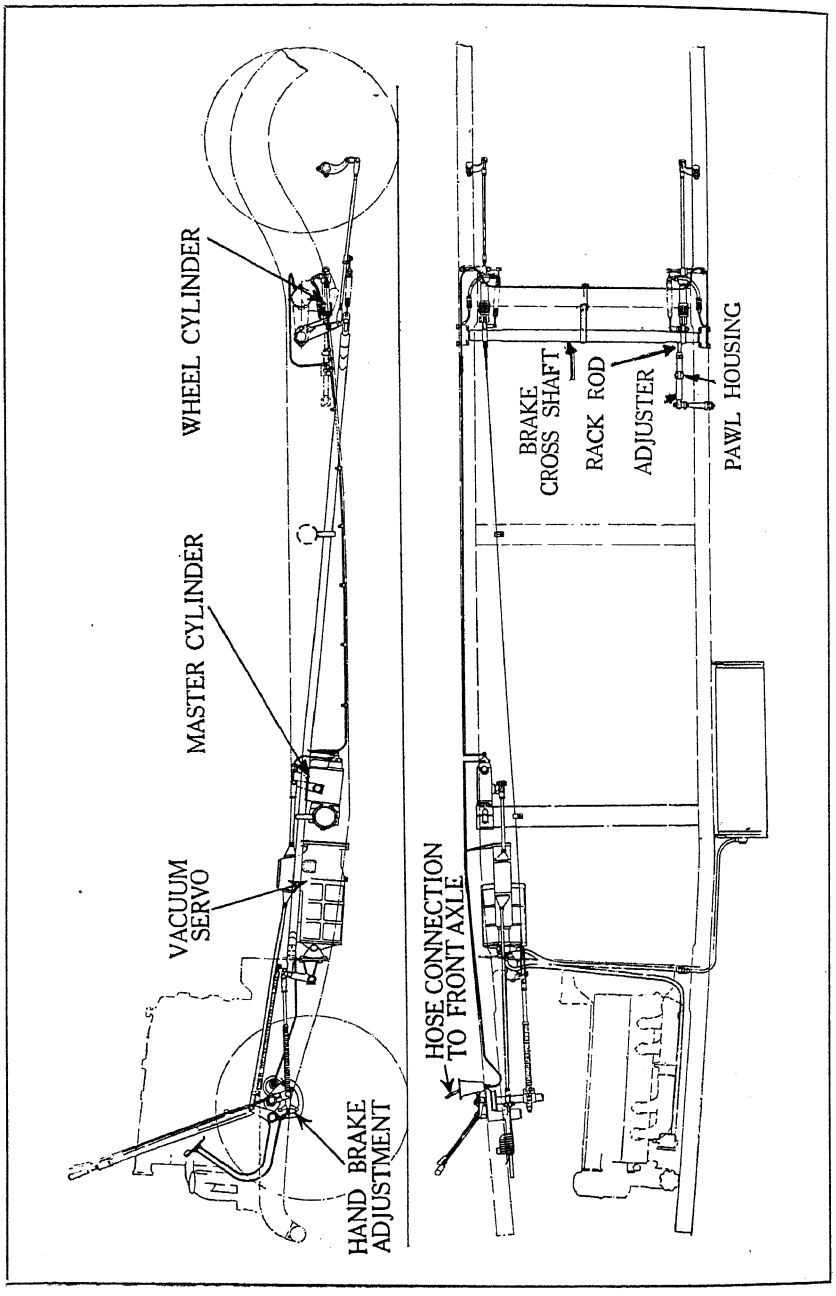


Fig. 9.—BRAKE LAYOUT
Showing another type of automatic adjuster for the rear brakes.

In the first type the automatic adjustment is provided for in the wheel cylinders. When all the movement provided in the wheel cylinder is used, it is necessary to pack out the shoes.

This should be done when the dimensions between the eye of the cylinder anchorage and the eye of the piston approaches 373 mm., which is the length when fully extended. After packing out the shoes, it is, of course, necessary to disconnect the piston from the camshaft lever and to push back the piston to its original position at the beginning of its stroke. Always make quite certain before reconnecting the piston and the camshaft lever that the spring-loaded ratchet pawl is in engagement with the teeth on the piston.

The second type of automatic adjustment is arranged as shown in Fig. 9. Attached to the centre of the swing lever is a rack-rod having a series of buttress teeth cut on it, these teeth engaging with a spring-loaded pawl having teeth of similar form. The pawl is held in a casing mounted on tubular member which acts as a guide for the rack-rod. The further extremity of the tubular member is slotted and is attached to a fixed pin anchored on the frame. Thus the brake rod and the adjuster gear are free to float laterally by the length of the slot, which provides a minimum initial clearance for the brake shoes. As brake wear takes place the movement of the brake rod will exceed that provided by the slotted hole, and the rack teeth will commence to override the pawl, until, as wear proceeds, the pawl will seat again in the next series of teeth, the original shoe clearance then being restored. Dirt and water are prevented from injuring the working parts by the provision of the gland nut and felt packing.

Two grooves are cut on the rack-rod and serve as an indication of the amount of adjustment that has been used in the automatic adjuster. When the groove nearest the fork end comes in line with the face of the gland nut, the amount of adjustment provided by the automatic adjuster is taken up, and it is necessary to insert, between the cam face and the brake shoe rubbing-pieces, the packing-pieces provided for this purpose. When this is done the adjuster mechanism must be reset to its original position with the rear cylinders fully compressed. To do this, remove the bolt from the slotted end of the adjuster, and turn the outer casing half a turn in either direction. This will disengage the pawl from the rack and enable the adjuster to be extended. Having been extended, the pawl must be re-engaged in the rack by returning the adjuster casing, care being taken that this is returned in the correct direction.

Front-brake Adjustment

Front-brake adjustment is provided for in the following manner:

The boss of the cam lever carries a worm engaging with suitable teeth cut in the brake camshaft. To adjust the brakes, the clamping bolt and the locknut on the end of the adjusting worm are first slackened off, and

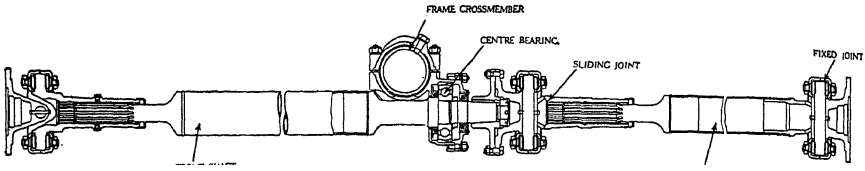


Fig. 10.—ARRANGEMENT OF PROPELLER SHAFT (WITH SPICER JOINTS)

then the worm is rotated, causing the brake camshaft to turn in relation to the cam lever and bringing the shoes nearer to the drum. When the brakes are adjusted, tighten clamping bolt and lock worm by means of the locknut.

When the front brakes are properly adjusted, there should not be more than 15 mm. of travel on the piston push-rod (*see* Fig. 5). This point should be checked periodically by getting someone to apply the brake whilst the movement is observed. Should the movement approach 30 mm., then the front brakes should be immediately adjusted as outlined above.

After a certain amount of adjustment has been taken up it will be necessary to insert packing-pieces as on the rear shoes. This is necessary when the notch cut on the face of the brake lever comes in line with the notch on the end of the brake camshaft.

PROPELLER SHAFT

A.E.C. tubular propeller shafts are made in two sections, and supported at the centre by an intermediate bearing mounted on one of the frame cross-members.

Three couplings are used, one immediately behind the gearbox, one immediately in front of the rear axle, and the third to the forward end of the rear half of the propeller shaft.

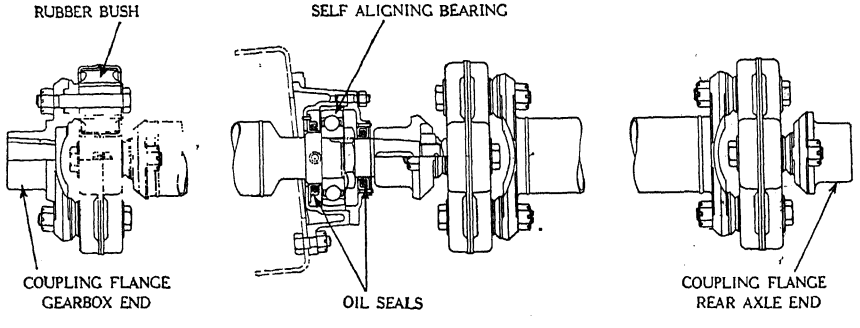


Fig. 11.—ARRANGEMENT OF FRONT AND REAR CARDAN SHAFTS (LAYRUB UNIVERSAL JOINTS)

The intermediate bearing, which is fitted to the rear end of the forward half of the propeller shaft, is a spherical seated ball bearing and is mounted in an oil-tight housing. A leather packing at each end serves to make the housing oil-tight.

Spicer or Layrub universal joints are used.

To remove Propeller Shafts

With Spicer universal joints, disconnect the flange of both the couplings of the rear half of the propeller shaft, slide the forward of the two couplings a little farther along its splines to disengage the spigot, and remove the rear half of the shaft complete.

Disconnect the flanges of the forward coupling, unbolt the intermediate bearing bracket from the cross-member, and the shaft can then be removed with the bearing in place.

The coupling at the forward end of both shafts can be removed by stripping it off the spline after first removing the knurled felt-retaining ring. That at the rear end of the rear half of the shaft is fitted to the shaft on a spline and locked by a nut.

To remove Layrub Coupling

Remove bolts securing coupling to each companion flange and prise the coupling away from each securing point in turn so as to disengage the spigots.

To remove Front Shaft complete with Centre Bearing

With Layrub joints, uncouple shaft at each end, leaving the universal coupling on the gearbox flange, and unbolt the centre-bearing housing. The shaft can now be removed from the rear, the hole in the cross-member being sufficiently large to enable the flange to pass through.

To remove Intermediate Bearing

Draw off the coupling flange, using the tool which is supplied in the tool-kit. Remove the cover over the bearing, and also the nut securing the ball bearing to the shaft, and tap the shaft out of the bearing and housing. The bearing may be tapped out of the housing.

Care must be exercised in handling this bearing, as the spherical is thin and is made only in soft steel. Leather packings, which are leaking, should be renewed.

Adjustment of the Spring Shackles

The shackles and the spring brackets should be kept adjusted so that the springs are just free but without having any real amount of slack.

To adjust, slacken off the clamp-bolts on the outer shackle, remove the split-pin from the nut on the shackle bolt and screw up the nut until just tight. Slacken off one half-turn, replace the split-pin, give the end of the

pin a tap with a hammer, in order to bring the clearance between the spring and the shackle, and tighten up the clamping bolts. The clamping bolts must always be kept screwed up tight.

The adjustment of the bracket at the forward end of the springs is performed in exactly the same manner. The side play is taken up by a sliding bush instead of drawing the shackles together, as in the case of the rear end.

To remove a shackle bolt, take out both clamping bolts and drive the pin out from the inside. In the case of the front shackle bolts of the front spring, the bolt may have to be drawn out, unless the radiator happens to have been removed, as with the radiator in position the inner end of the pin is not accessible.

Replacing the Springs

When replacing the springs, the greatest attention must be paid to tightening the axle bolts. This applies to both front and rear springs, but particular attention must be given to the rear ones. The bolts must be pulled up with a 4-ft. spanner, and all bolts of a spring tightened equally.

When assembling the shackles make sure that the slot in the pin for the clamping bolt is in line with the hole in the shackle.

After assembly, make sure that the oil-holes are lined up. This may be done by giving the shackle a liberal dose of oil and seeing that the oil gets out at both ends of both pins.

ROAD SPRINGS AND SPRING BUSHES

By GEORGE T. CLARKE, F.I.M.T.

(*Consulting Technical Editor to "Motor Commerce"*)

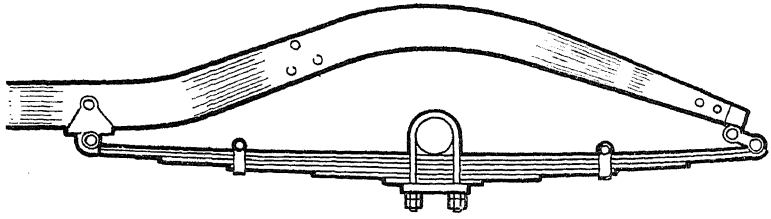
SPRINGS play a very important part in motor-car construction, but from their continued failure seem to have been somewhat neglected by the designer. On the other hand, those drivers who do have trouble with springs seem to be very much out of proportion to those who do not have trouble at all. Inquiry at large repair stations will prove that where springs fail it is mostly a failure on the part of the driver and not of any particular make of car. The great mortality in shock absorbers, however, leads to the supposition that the designer of the car places too much reliance on the absorber instead of the spring. Here, we are not dealing with the spring as fitted to the car in the first instance, but to the cause of failure and the repair and perhaps improvement of performance under the condition in which it has to function.

Causes of Spring Failure—Overloading

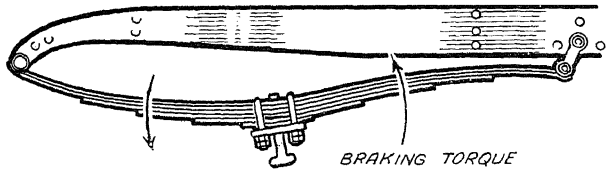
One great cause of trouble is overloading, especially at the rear of a car, when the driver carries a full complement of passengers and a pile of luggage on the rear carrier (Fig. 1). In this instance, the rear shackle is at such an angle that with each excessive bump it has a tendency to fracture the main leaf, on account of the angular movement being restricted, until, in one direction, it is almost solid with the spring. Observation often shows the rear springs in this condition before the start on a long journey over rough roads, either through actual overloading or through fatigue due to neglect. By many it is thought that the spring should last the life of the car if lubrication is carried out regularly, and without any other attention. Every part of every car should be inspected and the condition of the springs taken well into account.

Excessive Braking

Another form of trouble is caused by the driver who overstrains the springs, specially the front ones, by excessive braking (Fig. 2). The illustration is purposely exaggerated to show what happens when the driver pulls up suddenly and throws the whole car on its haunches, so to speak. It is admitted that in cases of emergency the spring should be capable of withstanding such strain, but where it is subjected to such misuse the spring should not be blamed for the inconsiderate action of the driver. This kind of inconsiderate driving is the cause of front-spring fractures, as shown in Fig. 3.

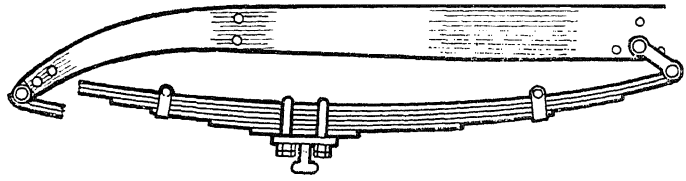


1 FLATTENED SPRING CAUSING INCORRECT ANGLE OF SHACKLE AND LEADING TO FRACTURE

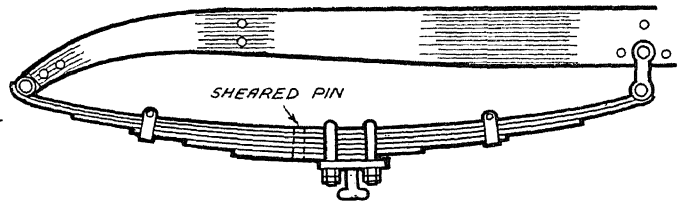


EXAGGERATED ACTION OF FRONT SPRING ON RAPID BRAKING

3 SEIZED SHACKLE PIN



4 LOOSE U-BOLTS OR SHEARED CENTRE BOLT



Figs. 1 *to* 4.—FAULTS IN SPRINGS AND THEIR CAUSES

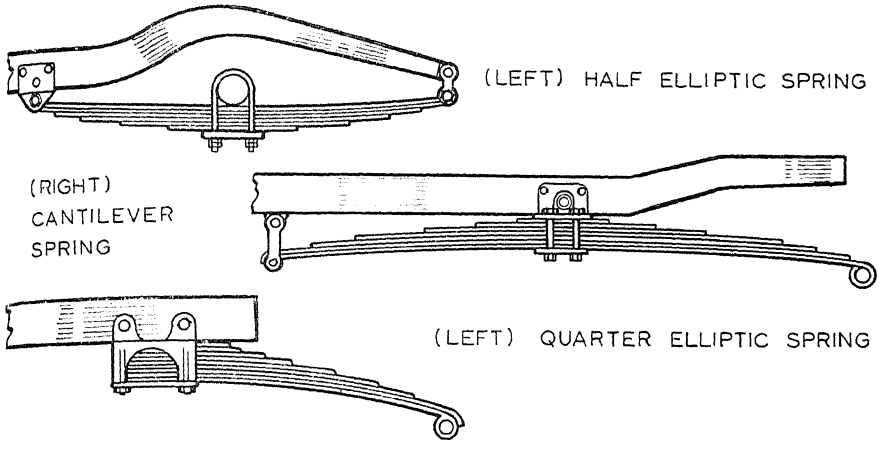


Fig. MAIN TYPES OF SPRINGS IN USE

Excessive braking leads to another trouble, in the form of the slacking off of the front spring U-bolts. The front axle should be continually checked, it being remembered that brakes on every car are more powerful than a few years ago, and with four-wheel brakes the leverage exerted by the driver has a tendency to pull the axles together, then, as the car slows up, the strain is released and the axles endeavour to take up their original positions. Brakes and their action is not part of this subject but are mentioned so that blame for failure should not be wholly placed on the design or material of the spring. Repeated spring failure can often be laid at the feet of the driver, although, as said, there is much need for a sound design.

Front-axle Movement

Front-axle movement will lead to the holding-down bolts moving along the spring, as shown in Fig. 4, and throwing more work on the spring centre bolt than it can possibly do.

Fit of the Centre Bolts

At this stage it may be as well to point out that all spring centre bolts should be a good fit, made of first-class mild steel, and that the head should actually fit the indentation in the spring platform. If they are properly made and from the right material, they will save many a spring fracture. Unfortunately, the writer has seen centre bolts that did not fit anyhow and could not, under any pretence whatever, be called a repair. Some bolts seem to have been made from any odd piece of iron, not steel, and so roughly screwed that on the slightest provocation the bolt fractured at the end of the badly cut thread. The thread should be allowed to " die out " on bolts of this description in exactly the same way as they do on a first-class big-end bolt.

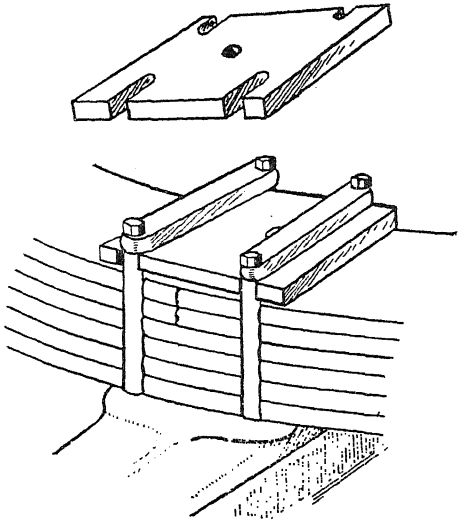


Fig. 6.—TEMPORARY REPAIR WHEN ARE BROKEN AT CENTRE

Types of Springs

Modern practice has eliminated the full elliptic spring, the main types of springing now used being the half-elliptic, quarter-elliptic, as on the Austin Seven; and the cantilever spring, as on the Rolls-Royce, etc. On the Ford and one or two other cars, the half-elliptic spring is set transversely instead of longitudinally, but the action is the same in both instances. Fig. 5 shows the three springs mentioned.

In some forms of front-wheel springing a helical spring is used; the spring gives little trouble, but the information as to adjustment is important and the instructions given with each design must be rigidly adhered to if the desired result is to be obtained. Instructions and advice are given for this type of springing in the articles dealing with the various cars.

Temporary Repair when Leaves are broken at Centre

Loose U-bolts lead to fractures of the spring at the centre, and frequently the trouble is not noticed until two or more leaves have given way. Fig. 6 gives an idea of a temporary repair until the failure can be dealt with at the end of the journey; the cause of the trouble is neglect.

The stock sizes of spring steels of all qualities are given in Table I.

TABLE I

STOCK SIZES OF SPRING STEELS

Width in inches	*Thickness in inches*
1	1/16 1/8 3/16 1/4
1 1/8	3/16
1 1/4	1/16 1/8 3/16 1/4 5/16 3/8
1 3/8	1/4
1 1/2	1/16 1/8 3/16 1/4 5/16 3/8
1 5/8	1/4
1 3/4	1/16 1/8 3/16 1/4 5/16 3/8 1/2
2	1/16 1/8 3/16 1/4 5/16 3/8 7/16 1/2 5/8
2 1/4	1/8 3/16 1/4 5/16 3/8
2 1/2	1/8 3/16 1/4 5/16 3/8 7/16 1/2
2 3/4 and 3	1/8 3/16 1/4 5/16 3/8 7/16 1/2
3 1/4	1/8 3/16 1/4 5/16 3/8
3 1/2	1/8 3/16 1/4 5/16 3/8 1/2
3 3/4	1/8 3/16 1/4 5/16 3/8
4	1/8 3/16 1/4 5/16 3/8 1/2

(*Buck & Hickman Limited*)

The Spring Steel Used

Car manufacturers, owing to requirements, are not now using ordinary carbon spring steel for spring making, but an alloy which stands up to the strain much better than plain spring steel, as shown in Table II.

TABLE II

COMPOSITION OF SPRING STEELS

Physical Properties			*Chemical Analysis*					
Steel	*Yield lb. sq. in.*	*Tensile Strength lb. sq. in.*	*C%*	*Mn%*	*Si%*	*Ni%*	*Cr%*	*Va%*
Carbon	145,600	123,000	·55	·6	·2	—	—	—
Chrome-Van.	184,800	194,000	·46	·57	·17	·15	1·4	·18
Silico-Man.	172,200	197,600	·52	1·05	1·95	—	·05	—

It will be noticed that the plain carbon steel has the lowest tensile strength, that chrome-vanadium has better strength, whilst silico-manganese has the highest tensile strength.

Whatever spring steel is used, the operator should stick to the same make and same quality so that he can, with certainty, master the hardening and tempering. It is not good to change around the steel used, as it gives the smith no chance whatever to gauge his material and manipulate it according to the varied requirements. The advice is, find the steel best suited to your purpose, both in requirements and the equipment at your command, master the working of the material, and then keep a good supply. One can never be sure of a good spring if the operator has to deal with a length picked up locally and which may be named a certain brand only so that a sale is effected.

Hardening and Tempering

Dealing with the hardening and tempering of spring leaves, the advice given is for the average garage repair shop, and not the smith's shop where springs are made on a large scale, the process in such a shop being entirely different from that practised by the ordinary spring-smith, using the ordinary hearth and small-shop system of hardening.

Judging the Temperature of the Steel

Any form of smithing entailing the hardening of steel must be carried out in semi-darkness, and the light entering the shop should not vary. In sunlight it is impossible to state the condition of the heated metal by colour, and it is by colour that the smith gauges his workmanship. A passing cloud will make all the difference in the appearance of a piece of

red-hot iron or steel, as there are varying degrees of "red hot." Overheating steel used for springs is fatal, as no one knows better than the practised smith.

TABLE III

HIGH TEMPERATURES JUDGED BY COLOUR IN A CORRECTLY LIGHTED BLACKSMITH'S SHOP

Degrees Centigrade	*Degrees Fahrenheit*	*Colour*
400	752	Red heat visible in dark
475	885	Red heat visible in twilight
525	975	Red heat visible in daylight
581	1077	Red heat visible in sunlight
700	1292	Dark red
800	1472	Dull cherry red
900	1652	Cherry red
1000	1832	Bright cherry red
1100	2012	Orange-red
1200	2191	Orange-yellow
1300	2372	Yellow-white
1400	2552	White welding heat
1500	2732	Brilliant white
1600	2912	Dazzling white

The Hardening Tank

The average spring steel should be brought to about 1,652° F., and plunged into clean cold water. If the forge bosh is not long enough the hardening should be done in a tank kept for the purpose. The writer has seen first one end and then the other end plunged in a small dirty bosh, and the operator wonder why his job has failed. If a special tank is used for the purpose, a handful of common salt can be added to increase the conductivity of the water. The tank, when not in use, should be covered, as it is likely to form the receptacle for anything not wanted by passers-by.

Tempering

Tempering is the after-process to bring down the hardness of the spring leaf to a working degree. The degree of tempering is about 426° C., or 800° F. The average smith heats the hardened leaf in a clean, dull fire and tries the heat with a piece of apple-wood. Apple-wood is not used because the original smith's shop started in the country and a piece of apple-wood came first to his hand, but because this tree suited his purpose in testing the heat he required. When the piece of apple-wood, stroked along the surface of the leaf, gives out sparks, plunge again into clean water, or oil, and allow to cool right off.

Tempering Oil

The oil mostly used by smiths for tempering is whale oil or some proprietary oil sold specially for the purpose, but the operator must not confuse the flash-point of an oil with the "fire test" of the same oil.

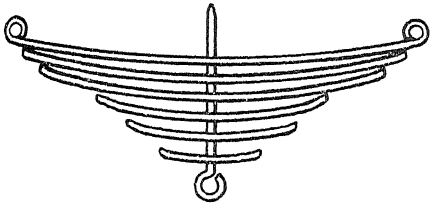


Fig. 7.—METHOD OF BUILDING UP A SPRING

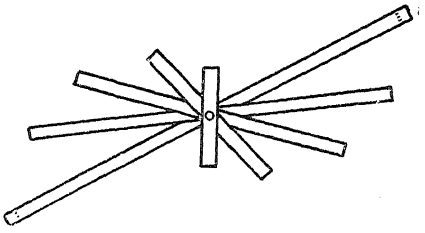


Fig. 8.—ASSEMBLING SPRING WITHOUT VICE

The distinction is as follows : The flash-point is the temperature at which the amount of vapour given off is sufficient to form an explosive mixture with the air over the surface of the oil so that it flares up when a flame is applied. When the oil is painted on a hot piece of iron or steel and the vaporisation is sufficiently rapid to light the oil and maintain the flame so that the oil takes fire and burns, the " fire test " point has been reached ; therefore in obtaining oil for your purpose be sure to give the correct definition.

Building up New Spring

In making up a new spring, the leaves will be compassed as in Fig. 7. The object in abutting the ends only is so that, when the spring is bolted up and used under working conditions, the whole of the leaves will be under stress, otherwise the ends would splay somewhat and do no work. The work is best carried out by laying the leaves on a large surface-plate (not of good quality, but of the type seen in the average smith's shop) so that the distance between the centre of each leaf can be gauged. Before final assembly the spring should be tried out to see if every leaf fits snugly to its fellow. This can be done with a large metal skewer through the centre-bolt holes, and the spring under a press of some sort.

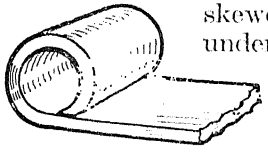


Fig. 9.—CORRECT FORMATION OF SPRING EYE

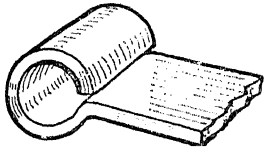


Fig. 10.—INCORRECT FORMATION OF SPRING EYE

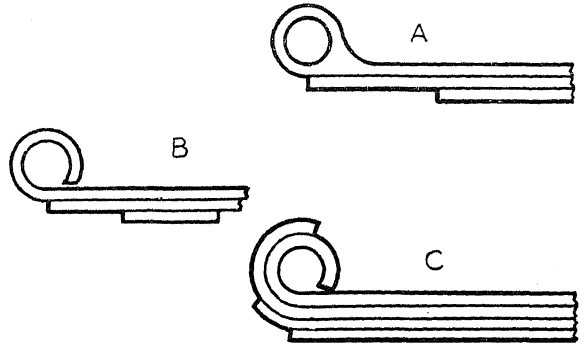


Fig. 11.—VARIETIES OF SPRING EYES AND MAIN LEAVES

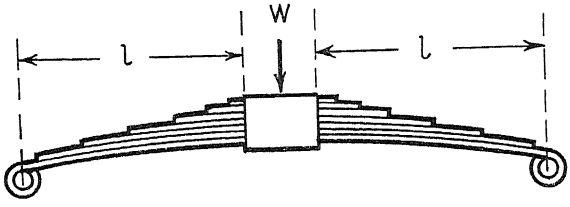


Fig. 12.—ILLUSTRATING LENGTH OF SPRING FOR CALCULATION PURPOSES

Final Assembly

To finally assemble the spring one may lay the leaves in their correct order but in the form of a star, so that the centre bolt can be installed and with the nut fitted on a few threads only to ensure its not coming off. The leaves can then be slipped round into the right direction, after which the centre-bolt nut can be finally tightened. Do not do up the nut until the bolt is ready to burst with the strain, but remember that it has work to do and is not merely for the purpose of keeping the leaves in their correct order (*see* Fig. 8).

Forming the Spring Eyes

In forming the spring eyes note the correct and incorrect formation clearly shown in Figs. 9 and 10.

Fig. 11 shows some of the main leaves that will be met with in the repair shop. It is not an economical proposition to make up a new leaf as at *A*, but if the shackle permits it is wise to shape leaves as at *C*, thus maintaining strength even if one does not follow actual design. The approved eye for insertion of the "Silentbloc" bush will be dealt with later.

Some Useful Spring Calculations

It may be necessary to make up springs, either on account of increased load, or to know what was originally intended by the designer. There are many reasons apart from actual manufacture why the repairer should be able to calculate springs, and as many workmen have no flair for figures the formula is given in as simple a form as possible.

Let S = fibre stress, assumed as 80,000 lb. per square inch for carbon spring steel.
E = modulus of elasticity = 25,400,000.
W = maximum carrying capacity of spring.
F = deflection of spring under load.
n = number of leaves in the spring.
b = width of leaves.
L = length of spring, less length of holding-down plate, or $l \times 2$ (*see* Fig. 12).

Example

A spring has 5 *leaves,* 2 *in. wide and* $\frac{1}{4}$ *in. thick, and the effective span is* 33 *in. What is the maximum carrying capacity ?*

The formula is $\frac{2\,Snbh^2}{3L}$, or

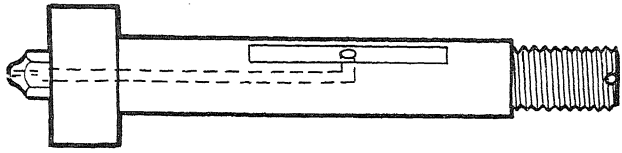


Fig. 13.—PLAIN SHACKLE PIN AND GREASE NIPPLE

$$\frac{2 \times \text{Fibre stress} \times \text{number of leaves} \times \text{thickness of leaves}^2}{3 \text{ times length of spring minus holding-down plate}} \text{ or}$$

$$\frac{2 \times 80{,}000 \times 5 \times 2 \times \cdot25^2}{3 \times 33} \text{ or } \frac{100{,}000}{99} = 1{,}010{\cdot}1 \text{ lb.} =$$

the maximum carrying capacity of the spring.

Another formula, giving a lower reading, and useful when one does not know the nature of the material, but assuming it is not higher than carbon steel, is $\frac{53{,}000\,nbh^2}{L}$ or $\frac{53{,}000 \times 5 \times 2 \times \cdot25^2}{33}$ or $\frac{530{,}000 \times \cdot0625}{33}$ or $\frac{33{,}125}{33} = 1{,}003{\cdot}4$ lb. as the maximum capacity of the spring.

The deflection of the same spring would be, using the formula : $\frac{SL^2}{4\,Eh}$ or $\frac{80{,}000 \times 33^2}{4 \times 25{,}400 \times \cdot25}$ or $\frac{80{,}000 \times 1{,}089}{25{,}400{,}000}$ or $\frac{87{,}120{,}000}{25{,}400{,}000} = 3{\cdot}429$ in. deflection.

Another formula, if in doubt as to the spring steel, is : $\frac{\cdot00079 \times L^2}{h}$ or $\frac{\cdot00079 \times 33^2}{\cdot25}$ or $\frac{\cdot00079 \times 1{,}089}{\cdot25}$ or $\frac{\cdot84031}{\cdot25} = 3{\cdot}44$ in. deflection.

The accompanying half-elliptic spring table compiled by *Machinery* in their handbook is a short and easy method of calculating half-elliptic springs, both for safe load and for the deflection with the same load. W is the safe load and F the deflection. The table is based upon a modulus of elasticity of 25,400,000, and a fibre stress under maximum load of 80,000 per square inch when all the leaves are fully graduated. The safe load on one leaf, 1 in. wide, is found by dividing the constant

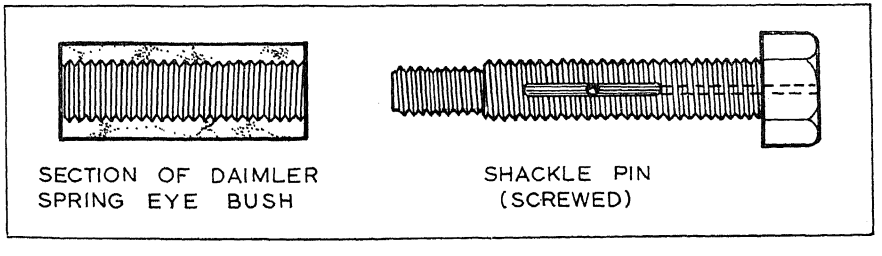
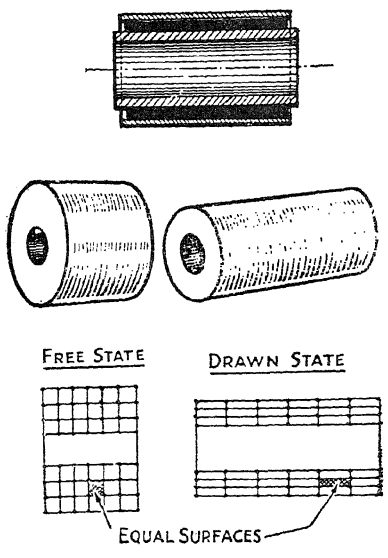


Fig. 14.—DAIMLER SCREWED BUSH AND PIN



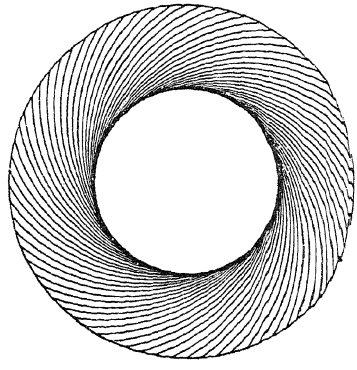


Fig. 15.—PRINCIPLES OF FORMATION OF "SILENTBLOC" BUSH

The upper pair of sketches on the left show the rubber bush before and after fitting. In the process of fitting, the material is compressed radially, as indicated by the diagrammatic sections shown in the corresponding lower pair of sketches on the left.

given in column W by the net span L. The corresponding deflection is found by multiplying the constant given in column F by the square of the net length of L.

TABLE IV

HALF-ELLIPTIC SPRING TABLE

Thickness of leaf in inches	*Constants*	
	W	F
$\frac{3}{16}$	1875	·00420
$\frac{1}{4}$	3333	·00315
$\frac{5}{16}$	5208	·00252
$\frac{3}{8}$	7500	·00210
$\frac{7}{16}$	10210	·00180
$\frac{1}{2}$	13330	·00157
$\frac{5}{8}$	20830	·00126

From *Machinery's Handbook.*

Example

Find the safe load of a half-elliptic fully graduated spring with 5 *leaves* 2 *in. wide and* $\frac{1}{4}$ *in. thick. The net length is* 36—3, *therefore the effective length is* 33 *in.*

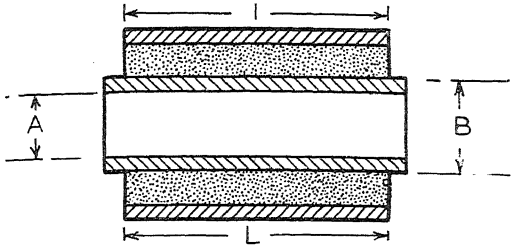


Fig. 16.—THE " SILENTBLOC " BUSH

A, Bore of inner tube. B, Outside diameter. L, Length of inner tube. I, Length of outer tube.

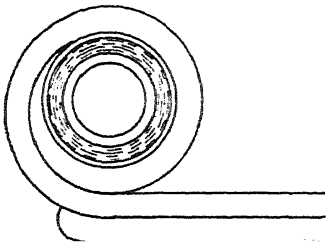


Fig. 17.—APPROVED SPRING EYE FOR " SILENTBLOC " BUSH

Load on one leaf 1 in. wide equals $\frac{3,333}{33}$ or 101·01 lb.

Load on one leaf 2 in. wide is therefore 2 × 101·01 or 202·02 lb.

Load on five 2-in. leaves is 5 × 202·02, totals 1,010·1 lb.

The corresponding deflection is :

$$\cdot 00315 \times 33^2 \text{ or } 3 \cdot 43 \text{ in.}$$

Shackle Pins and Bushes

For many years shackle pins and bushes were but a primitive method of securing the spring to the chassis frame. The supply of lubricant was haphazard, and both pin and bush, by being smothered with grease on the outside, gathered all the road dust, thus forming an excellent abrasive with which to wear out the whole of the securing mechanism. Fig. 13 will be recognised as the very poor effort in this direction.

The Daimler Company introduced an improvement in the nature of a bush screwed inside, with a hardened pin screwed on the outside. This was very satisfactory in the fact that it prevented " slogger " within the shackle (one of the forms of wheel wobble with a neglected spring anchorage). It also offered a larger wearing surface.

The " Silentbloc " Bush

In latter years the majority of manufacturers have installed what is known as the " Silentbloc " bush. A description of the principle may therefore be of some assistance, along with the tolerances of the most popular sizes used.

This form of bush consists essentially of an inner bush or tube and an outer concentric sleeve, the space between being filled with an elastic and insulating material in the form of a cylindrical ring, which is forced into position. In the assembly of the elastic ring, the longitudinal fibres are stretched, and when in position between the sleeves the effort made by the ring to regain its original shape exerts a radial compression force of such intensity that no slip can take place between the elastic ring and the sleeves. The result is that all relative movement between the centre

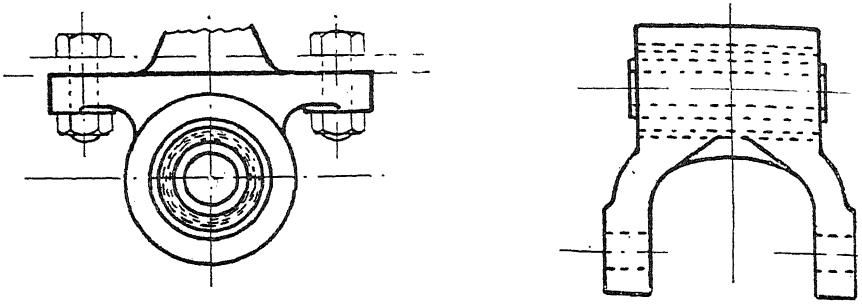


Fig. 18.—"SILENTBLOC" BUSHES IN CHASSIS BRACKETS AND SHACKLES

and the outer tubes is limited to a circular direction only, and consequently any angular movement of the one part in relation to the other is possible without any friction or wear taking place, namely, angular movement only and not rotative. It will be seen the principle is entirely different from either of the bushes previously described.

TABLE V

"SILENTBLOC" BUSHES (Letters A, B, L, I refer to *Fig.* 16)

Series E.1000 and E.2000 (English Dimensions)

Limits of Manufacture

Outside Diameter	*Inches*			
Inches	A	B	I	L
$\frac{9}{16}$–$\frac{11}{16}$	+ ·003 — 0	+ ·002 — 0	+ ·005 — 0	+ ·002 — 0
$\frac{3}{4}$–$\frac{7}{8}$	+ ·005 — 0	+ ·002 — 0	+ ·005 — 0	+ ·002 — 0
$\frac{7}{8}$–5$\frac{1}{2}$	+ ·005 — 0	+ ·005 — 0	+ ·005 — 0	+ ·002 — 0

Series M.1000 and M.2000 (Metric Dimensions)

Limits of Manufacture

Outside Diameter	*Millimetres*			
Millimetres	A	B	I	L
6–10	+ ·05 — 0	+ ·05 — 0	+ ·10 — 0	+ ·10 — 0
11–24	+ ·075 — 0	+ ·05 — 0	+ ·10 — 0	+ ·10 — 0
25–34	+ ·075 — 0	+ ·10 — 0	+ ·10 — 0	+ ·10 — 0
35–38	+ ·10 — 0	+ ·10 — 0	+ ·10 — 0	+ ·10 — 0

Fig. 19.—Methods of fixing "Silentbloc" bushes to chassis brackets and solid dumb-irons

Fig. 20. Methods of fixing "Silentbloc" bushes to commercial-vehicle dumb-irons

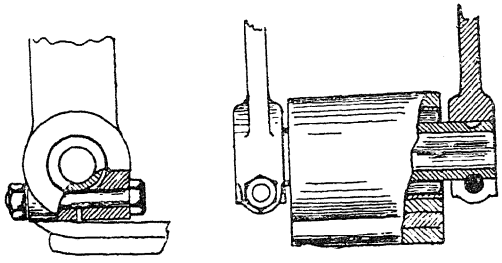


Fig. 21.—"SILENTBLOC" BUSH IN COMMERCIAL-VEHICLE SHACKLE

The permissible angular movement allowed by the stretch of the radial fibres is limited only by the fact that the external torsional movement applied must be less than the internal movement of resistance given by the frictional force of the elastic ring on the surfaces of contact.

The angle of torsion can be varied by an alteration to the dimensions of the elastic ring before assembly. In practice, approximately 20°–45° of movement on either side of the neutral position is allowed for, and this can be increased or decreased by any particular application. If the angular movement allowed be exceeded, slip will take place between the elastic ring and the sleeve, with the result that the "Silentbloc" will then, momentarily, function as an ordinary bearing. It is, however, important to note that in this case the "Silentbloc" will take up a new neutral position and will function correctly through a given angle on either side of the new point taken up.

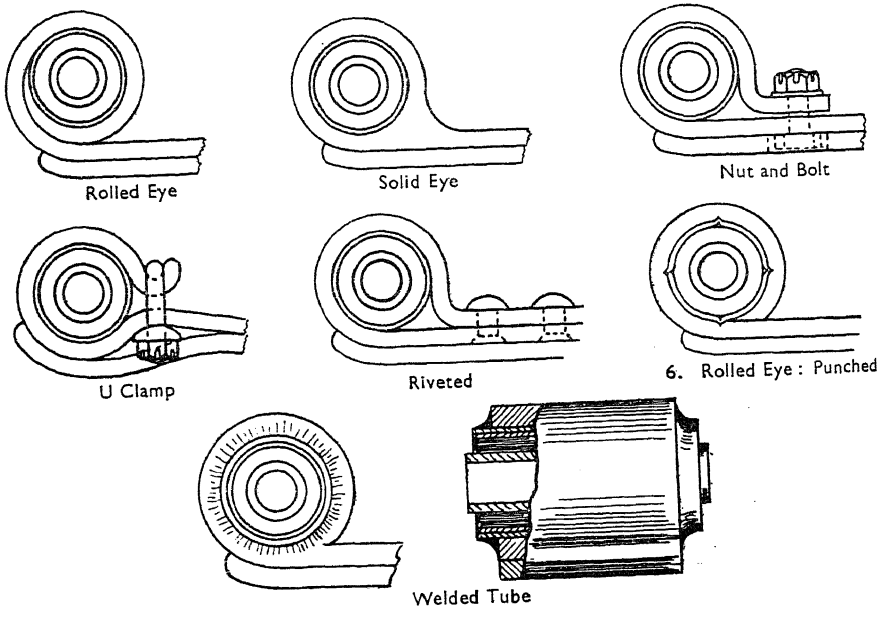


Fig. 22.—FIXING "SILENTBLOC" BUSHES TO SPRING EYES

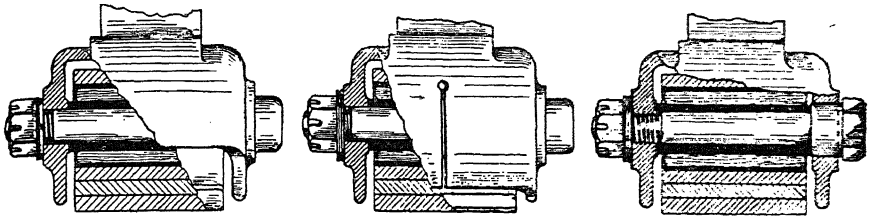


Fig. 23.—"SILENTBLOC" BUSHES FIXED TO OPEN DUMB IRONS AND CHASSIS BRACKETS
The sawcut in the housing gives greater flexibility.

It will be noted that all lateral or end movement is limited, although for other purposes this bush can be made to permit end play. This is not necessary with its application to the springing of cars.

It will be apparent that the adhesion of the elastic ring to the inner and outer sleeves, in addition to allowing angular movement without friction, provides an airtight joint against liquids and gases; further, owing to the composition of the bushing it tends to absorb tremors and vibration (*see* Fig. 15).

Fig. 16 illustrates the bush, whilst Tables V–VII give the limits to which they are manufactured.

TABLE VI

TOLERANCES FOR PRESS FITS IN SPRING EYES (*see* Fig. 17)

English sizes		*Metric Sizes*	
Nominal diameter of Silentbloc (outside) Inches	*Limits in Spring Eye Inches*	*Nominal diameter of Silentbloc (outside) Millimetres*	*Limits in Spring Eye Millimetres*
$\frac{9}{16}$–$\frac{7}{8}$	— ·010 — ·020	21–25	— ·30 — ·60
$\frac{15}{16}$–$1\frac{1}{8}$	— ·016 — ·026	26–29	— ·40 — ·70
$1\frac{3}{16}$–$1\frac{3}{8}$	— ·025 — ·035	30–35	— ·60 — ·90
$1\frac{7}{16}$–$1\frac{5}{8}$	— ·028 — ·038	36–40	— ·70 — 1·00
$1\frac{11}{16}$–$2\frac{1}{8}$	— ·034 — ·044	41–54	— ·80 — 1·20
$2\frac{3}{16}$–$2\frac{3}{4}$	— ·040 — ·055	55–70	— 1·00 — 1·40

Silentbloc Arrangements

The standard Silentbloc has a comparatively thin inner tube, through which the bolt passes. It is, however, possible to use a much thicker tube or even a solid centre which would project either end, in which case a bolt would not be necessary.

TABLE VII

TOLERANCES FOR CHASSIS BRACKETS AND SHACKLES (*see* Fig. 18)

English Sizes		*Metric Sizes*	
Nominal outside diameter of Silentbloc Inches	*Limits in Bracket Inches*	*Nominal outside diameter of Silentbloc Millimetres*	*Limits in Bracket Millimetres*
$\frac{5}{16}$–$1\frac{9}{16}$	– ·002 – ·003	21–40	– ·05 – ·07
$1\frac{5}{8}$–2	– ·0025 – ·0035	41–50	– ·06 – ·08
$2\frac{1}{16}$–4	– ·003 – ·004	51–70	– ·06 – ·085
		71–80	– ·06 – ·09

With the smaller sizes of Silentbloc, the friction at the end of the inner tube is sufficient to prevent rotation, but with the larger sizes it is advisable to have a positive fixing. Several approved methods are shown in Figs. 19, 20, and 21. The usual method of fixing the outer tube is by force-fit in the bracket or spring eye, and this has been found satisfactory for all sizes. The bush should always be assembled in its neutral position, so that the angular movement is the same in both directions. Always press on the outer tube when assembling, and never on the inner tube.

Many shackle-bolt housings were not originally intended to take the Silentbloc bush, but when this bush is fitted it is as well to make a saw-cut down the housing, as Fig. 23, so that the inner tube of the bush can be pinched tightly. The cover on the bracket, or shackle, was intended to stiffen the housing so that the spring could not be pinched. As the situation is now entirely reversed, the saw-cut is an advantage, and not, as may be supposed, a method of surmounting an unforeseen difficulty.

Helical Springs

The various forms of front suspension mostly use round helical springs, but the design and layout of the various methods are given under the headings of the suspension themselves, therefore it will be necessary in this article to deal only with the value of the springs, leaving it to the other sections to describe how they are actually used.

The formula is somewhat lengthy and complicated, but it is hoped that the undermentioned information will assist the operator or mechanic to locate their values.

All dimensions are in inches and weights in pounds.

W = maximum load in pounds or the load equivalent to the maximum deflection.

W_1 = in pounds equivalent to any deflection less than the maximum.

D = the mean diameter of the spring in inches = the outside diameter minus the wire diameter.

d = diameter of the wire.

F = total deflection in inches from free to the fully compressed length.

F_1 = any deflection from the free length but less than the solid length.

A = deflection between two loads.

N = length of free or unloaded spring.

h = length of spring when compressed solid.

H = number of effective working coils. This value is usually $1\frac{1}{2}$ or 2 less than the total number of coils for springs having squared ends.

L = length of wire from which the spring is made.

G = torsional modulus of elasticity (10,500,000).

The formulas and examples all deal with a helical spring having an outside diameter of 3·5 in., a wire diameter of 0·5 in., and a modulus of elasticity of 10,500,000 lb.

Required to find the maximum load (W) *for the maximum deflection* (F)

$D = 3{\cdot}5 - 0{\cdot}5 = 3$ in.

$H = 10{\cdot}5$ in. ; $h = 6$ in.

$F = 10{\cdot}5 - 6 = 4{\cdot}5$ in.

$N = h + d - 2 = 6 \div 0{\cdot}5 - 2 =$ *active coils.*

The formula is :

$$W = \frac{Gd^4F}{8ND^3} \text{ or } \frac{10{,}500{,}000 \times 0{\cdot}5^4 \times 4{\cdot}5}{8 \times 10 \times 3^3} \text{ or } \frac{10{,}500{,}000}{10} \frac{0{\cdot}0625 \times 4{\cdot}5}{-} \text{ or } \frac{2{,}953{,}125}{2{,}160} = 1{,}367 :$$ (in round figures) 1,370 lb.

Another example :

Load required (W_1) *for any deflection* (F) :

$D = 3{\cdot}5 - 0{\cdot}5 = 3$ in.

$F_1 = 2{\cdot}5$ (*assumed value*).

$N = 6 \div 0{\cdot}5 - 2 = 10$ *active coils.*

The formula is :

$$W^1 = \frac{Gd^4F_1}{8ND^3} \text{ or } \frac{10{,}500{,}000 \times 0{\cdot}5^4 \times 2{\cdot}5}{8 \times 10 \times 3^3} \text{ or } \frac{1{,}640{,}625}{2{,}160} = 759$$

(in round figures) 760 lb.

Another example :

Total deflection from free to solid (F) *length :*

$W = 1{,}370$ lb.

$N = 6 \div - 2 = 10$ *active coils.*

$D = 3{\cdot}5 - 0{\cdot}5 = 3$ in.

The formula is :

$$F \frac{W8ND^3}{Gd^4} \text{ or } \frac{1{,}370 \times 8 \times 10 \times 3^3}{10{,}500{,}000 \times 0{\cdot}5^4} \text{ or } \frac{1{,}370 \times 80 \times 27}{656{,}250} \text{ or } \frac{2{,}959{,}200}{656{,}250}$$

4·5 in.

Last example :

Deflection required (F_1) *for any load less than* W :

$W_1 = 760$ *lb.*

$N = 6 \div 0{\cdot}5 - 2 = 10$ *active coils.*

$D = 3{\cdot}5 - 0{\cdot}5 = 3$ in.

The formula is :

$$F_1 = \frac{W_1 8 N D^3}{G d^4} \quad \frac{760 \times 8 \times 10 \times 3^3}{10{,}500{,}000 \times 0{\cdot}5^4}$$

$$= \frac{1{,}641{,}600}{656{,}250} = 2{\cdot}5 \text{ in.}$$

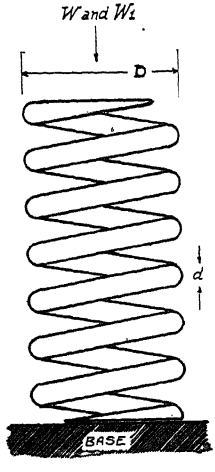


Fig. 24.—HELICAL SPRING

It is as well to remember that some of the steel from which springs are made is of special quality, both for strength and the resistance to the atmosphere and acids ; therefore the operator should obtain from the manufacturer the data on which the particular material is based.

SPRING ASSEMBLY HINTS

Spring Wedges and Steering Castor Action

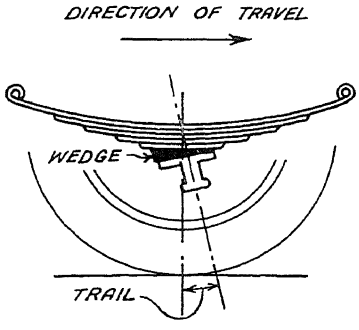
In order to introduce or increase the castor action of the front wheels of a car, wedges are sometimes fitted between the front springs and the axle plates so as to incline the steering pivot pins backwards, as shown in Fig. 25. Each wedge consists of a piece of tapered metal with a hole in the centre for the spring dowel pin to pass through.

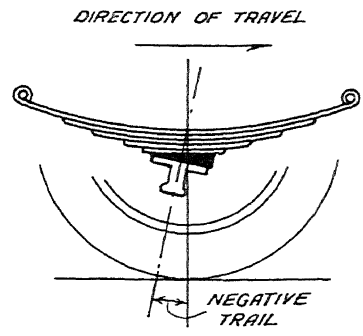
In replacing a spring care should be taken not to omit the wedge, with the possible exception of a case where the springs have just been reset, the wedges having been previously fitted solely for the purpose of correcting " S " distortion of the spring caused by breaking torque. In such a case the wedges may be omitted if the springs have been restored to their correct shape.

It is even more important that the wedges be replaced in the correct manner, for if they be reversed, with the thin end of the taper to the rear, the steering king pins will be inclined forward, thus introducing negative trail and making the steering practically uncontrollable.

Location of Centre Bolt

The wedges should not be so thick that the head of the spring centre bolt does not engage with the hole in the axle spring table, otherwise the axle may creep out of position. On the other hand, should a wedge be removed it is advisable to ascertain that the head of the bolt is not too long, for if it should bottom in the hole it would be impossible for the spring to seat properly. On tightening the U-bolts the tendency would





Figs. 25 *and* 25*a*.—FRONT SPRINGS ARE SOMETIMES FITTED WITH WEDGES BETWEEN THE SPRINGS AND THE AXLE

It is important when fitting the springs to replace these wedges with the thin edge forward, for if they be reversed the castor action will be negatived and the steering will become unmanageable.

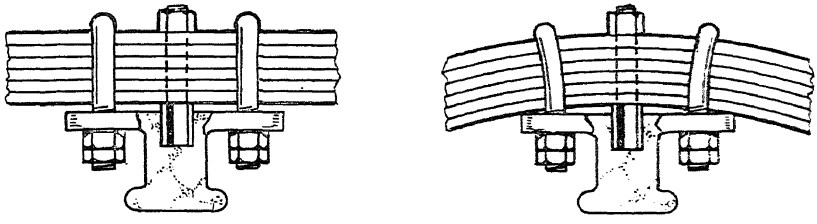


Fig. 26.—LOCATION OF CENTRE BOLT

Should the dowel head of the centre bolt bottom in the hole in the axle spring table the spring will not seat properly, and on tightening the U-bolts both the spring and the U-bolts may be bent, with the added risk of shearing the bolts or causing a spring fracture.

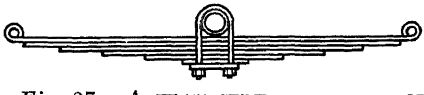


Fig. 27.—A FLAT SPRING SHOULD NOT BE CONFUSED WITH ONE WHICH IS DESIGNED WITHOUT CAMBER AS SHOWN HERE

The position of the shackles will reveal the difference; with the former the shackle assumes an acute angle, whereas with the latter it is approximately vertical under normal load.

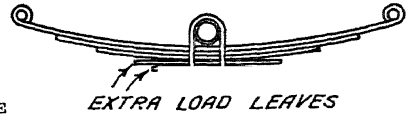


Fig. 28.—ADDITIONAL LEAVES EITHER FLAT OR OF REVERSE CAMBER ARE SOMETIMES FITTED TO A SPRING

They come into operation under heavy loads and should not be reversed or set up.

SPRING ASSEMBLY HINTS

be to pull the spring out of shape, if not to break it, as shown in Fig. 26. There is also a likelihood of the U-bolts snapping due to the additional strain imposed.

Flat Springs and Supplementary Leaves

Because a spring appears to be flat it does not necessarily follow that it has become soft or "settled," since it may be designed with little or no camber. A rough and ready way to differentiate between the two conditions is to examine the position of the shackles. When a cambered spring flattens, the increased length causes the shackle or shackles to assume almost a horizontal position, but with a normally flat spring the shackles are more or less vertical under ordinary load conditions.

Sometimes the first one or two of the shorter leaves of a spring are flat or have reversed camber so that they stand away from adjacent leaves, as illustrated in Fig. 28. This should not be confused with the splayed leaves of a weak spring. The idea of these supplementary leaves is to provide the right degree of spring strength under varying conditions of load. Thus, when the car is lightly loaded the upper leaves only are operative, but when the load is increased the additional flexion of the spring brings the supplementary leaves into action so that the stiffness of the spring increases with the increase in load. These supplementary leaves should not be reversed when reassembling the spring, nor should they be set up.

VEHICLE BRAKE TESTING

THE first requirement in carrying out brake tests on any vehicle is a thorough understanding of what one is about to measure and the type of brake performance which can be expected under the prevailing conditions, together with the possibilities of the available measuring instrument or machine.

How Road Conditions Affect Braking

In the first place the brake force on the speed of a vehicle is limited finally by the friction between its tyres and the ground. The value of this friction varies widely according to prevailing conditions. On suitable roads, with good tyres, steering, and road holding, values of unity coefficient of friction, or even slightly over, have been recorded. On a wet, ice-bound road, on the other hand, the same vehicle may give an adhesion coefficient of friction of ·1 or even less, in spite of the fact that the vehicle and its brakes are still in the same excellent condition. In the first case, it will be possible to make use of a braking force equal to or even slightly in excess of the car's own weight, whereas under the latter condition any attempt to use a force more than $\frac{1}{10}$th of the vehicle's weight will put it out of control.

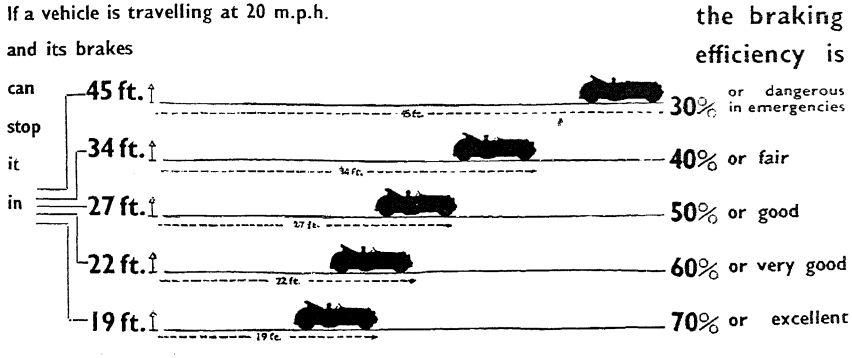


Fig. 1.—STOPPING DISTANCE AND BRAKING EFFICIENCY AT 20 MILES PER HOUR ON GOOD DRY LEVEL ROADS

In this country, the police generally insist on a minimum of 30 per cent. braking efficiency. With brakes and linings in good order, the average commercial vehicle, unless grossly overloaded, will give a value of around 50 per cent. and modern private cars 70 per cent. and over on good dry level roads.

What is meant by 100-per-cent. Brake Efficiency

Perhaps the principal law covering any change of speed of a vehicle in horizontal motion is that a force equal to its own weight will, when acting on it, increase or decrease its speed by 22 m.p.h. for every second the force is in action. Similarly, a force equal to half the vehicle's weight will change its speed by 11 m.p.h. during each second it is in action, and so on for any other proportion the force may bear to the vehicle's weight. All tables giving stopping-distances at different speeds and brake performances are based on this fact, and the acceptance by the motor trade and users generally that a coefficient of friction between tyres and road of unity with its corresponding maximum brake force represents 100 per cent. braking.

How the Stopping-distance Varies with the Speed

It will be seen from any braking chart that, for a given braking performance, stopping-distance increases as the square of the speed, i.e. if the speed is doubled the stopping distance is four times as great, and this again depends upon the facts already stated. If a vehicle travelling at 30 m.p.h. is braked by a force equal to its own weight, it will lose 22 m.p.h. per second and will therefore take approximately 1·36 secs. to lose 30 m.p.h. and come to rest. Providing the brake force is constant, its average speed during braking will be half its initial speed, or 22 ft. per second, and as this average speed is maintained for 1·36 secs. the stopping-distance will be 30 ft. For the same brake performance, however, from 60 m.p.h. the time taken in losing all speed will be twice as long, or 2·72 secs., but in addition the average speed during the stopping-time will be twice as great, or 44 ft. per second, thus giving a stopping-distance of 120 ft., or four times that from 30 m.p.h.

Why Stop-watch Brake Testing is Inefficient

Accurate brake testing is impossible without the aid of some form of instrument or machine. The old methods of applying a vehicle's brakes when passing a mark at the side of the road and subsequently measuring the stopping-distance, or the alternative stop-watch measurement of braking time, both of which introduce the human element and speedometer errors, should, by now, be extinct. An error of plus or minus 2 m.p.h. at 20 m.p.h. will create a similar error of 20 per cent. in estimating whether a set of brakes is satisfactory or not. Similarly, at the same speed an anticipation or lag, by the driver, of $\frac{1}{5}$th of a second in applying the brake will cause a further error of around 30 per cent., and it will be impossible to say whether this latter error is in addition to or corrects a faulty speedometer reading. Timing the duration of the stop introduces errors of a similar magnitude.

Fixed Floor Brake-testing Machines

Equipment for road-vehicle brake testing can be divided into two classes—machines and instruments. The machines, which are difficult or impossible to use on the road, measure the individual brake force exerted at each tyre periphery when the brakes are applied, and again can be divided into two types.

The first type is equipped with a pair of rollers for each wheel, the vehicle is driven on to these rollers, movement of the vehicle prevented by anchoring the front axle or some other rigid portion of the vehicle's chassis to an external anchorage, and the rollers are driven either by power or manually. The vehicle's brakes are applied by means of a pedal effort, and the resulting brake resistance at the effective tyre radius of each wheel is indicated by a transmission dynamometer in the roller drive which continuously weighs the braking force.

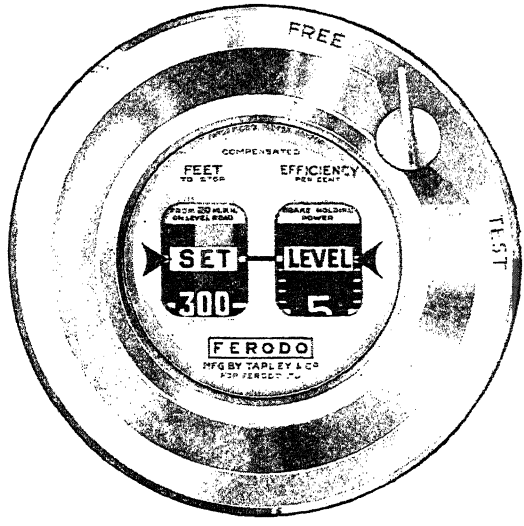


Fig. 2.—THE FERODO BRAKE-TESTING METER

The instrument is mounted on the car and set to zero. The car is then driven at any speed over 10 m.p.h. and the brake applied. The percentage efficiency of the brake and the distance in feet in which the car can be stopped from a speed of 20 m.p.h. can be read off the two scales. A table giving the corresponding stopping distances from other speeds is shown on page 492.

These machines usually give a direct reading for each wheel in terms of lb. drag at effective tyre radius. This type of machine is manufactured in a range of sizes from the light type, consisting of a single unit which can be applied individually to each wheel in turn and turned by hand to obtain a reading, to the large, heavy type in which each pair of rollers is driven by an individual motor and the machine is sunk into the sides of an inspection pit with the rollers at floor level. This latter type of machine, in its heaviest form, is suitable for measuring the brake drag on the largest commercial vehicles and buses.

In addition to measuring the total brake power, this type of machine gives independent readings at each wheel, and therefore indicates to the operator the condition of balance between the brakes on each axle and also the distribution between the axles themselves. The sum of the indicator readings divided by the total weight of the vehicle can be expressed as braking percentage.

Another type of the fixed-floor machine has four long checkered floor plates sunk flush with a drive-way, and with this type the vehicle is driven on to the plates and the brakes applied. Each of these plates is mounted on runners so that the plates are capable of movement, but movement is resisted by either calibrated springs or hydraulic cylinders. A pillar is mounted at one side of the runway, clear of the vehicle's track, and in the case of the spring-loaded runners is equipped with dials which indicate the brake force at each wheel as weighed by the springs.

As each individual test occupies a very short period of time, each indicator is fitted with a tell-tale which remains at the maximum figure recorded. In the hydraulic type, a column of liquid for each individual platform is forced up a calibrated tube and acts as a similar indicator. It will be evident that this type of brake-testing machine measures the brake drag at each tyre and gives similar readings to those obtained from the roller type.

Brake Testing on the Road

Brake testing on the road from any speed is usually carried out with the aid of an inertia instrument, and these can be generally classified into two types, both depending on inertia effects during speed change, but in one case the inertia of a mass mounted as a pendulum is used, while the other depends on the similar inertia of a column of liquid in a closed circuit of glass tubing. In both cases, application of the vehicle's brakes disturbs the attitude of repose of the pendulum or the column of liquid as in each

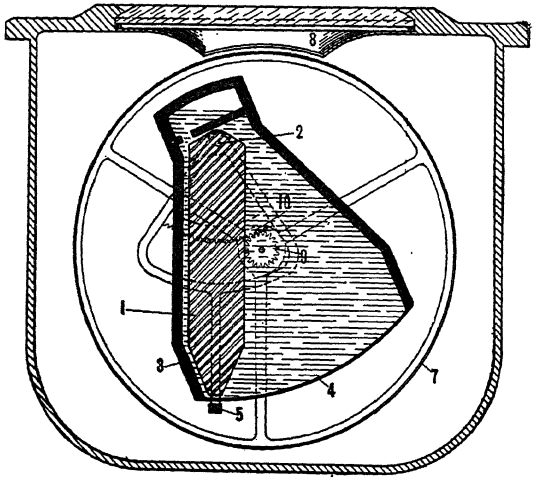


Fig. 3 (LEFT).—PRINCIPLE OF FERODO BRAKE TESTER

Showing permanent magnet pendulum 1, suspended on centre 2, and enclosed in sealed box 3 filled with suitable damping fluid. A light armature 5 is so arranged that by magnetic attraction from the magnetic pendulum it follows the movement of the pendulum. The movement of the armature is magnified and transferred to the revolving indicating scale 7 by means of toothed segment and pinion 10 and 9. The scale is seen through window 8. When the brake is applied the pendulum will take up a position corresponding to the rate of deceleration, which is therefore recorded on the scale. The scale retaining mechanism is not shown in the diagram.

case the free mass adopts a new position which depends directly on the rate at which speed changes.

A freely suspended pendulum in a vehicle which is either stationary or moving at constant speed will, of course, retain its normal vertical position, but during any change of speed the pendulum deflects from the vertical, and, providing the speed changes at constant rate, the rate of deceleration, or, for the matter of that, acceleration, is always correctly represented by the tangent of the angle to which the pendulum is deflected from the vertical.

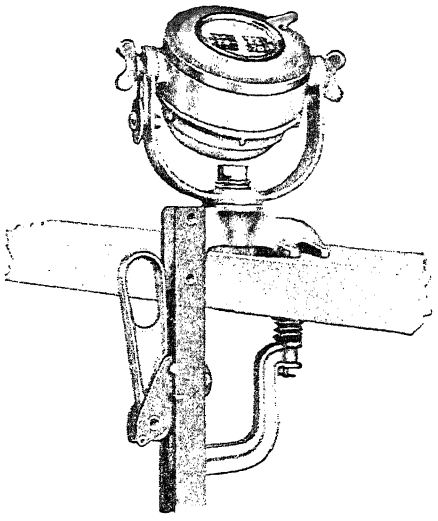


Fig. 4.—How Ferodo brake-testing meter is mounted on running-board of car for a brake test

Ferodo Brake-testing Meter

Perhaps the best-known instrument of this type is the Ferodo brake-testing meter (Figs. 2 and 3), which consists of a powerful permanent magnet suspended at one end on anti-friction bearings in a non-magnetic casing which is almost completely filled with a light damping liquid. The bottom end of this pendulum swings just clear of a thin brass diaphragm, and outside this diaphragm a light armature is suspended from co-axial pivots so that the armature follows every movement of the pendulum pole inside the casing. The armature is connected through instrument gearing to a cylindrical dial encircling the mechanism, and the calibration on the dial can be seen through a small window in the top of the instrument outer casing. The dial itself gives two separate readings, the left-hand one reading the equivalent stopping-distance at any particular rate of retardation from 20 m.p.h., and the right-hand scale giving the corresponding reading of brake performance or "efficiency." The meaning of this brake-performance figure expressed as a percentage has been explained earlier in this article.

Clamping the Ferodo Meter to the Car

The instrument has a universal mounting terminating in a quick-acting clamp, and all that is needed is to clamp it to some rigid portion of the vehicle and, with the vehicle standing on level ground and the instrument controlling lever in the free position, set the instrument so that the marks at the side of the window coincide with zero, or set level marking on the

TABLE I.—CORRESPONDING STOPPING DISTANCES AT DIFFERENT SPEEDS

(all measurements made on level road)

Brake Efficiency per cent. Meter Reading	*Distance to Stop in Feet*				
	From 20 *m.p.h.*	*From* 30 *m.p.h.*	*From* 40 *m.p.h.*	*From* 50 *m.p.h.*	*From* 60 *m.p.h.*
2	670	1510	2680	4170	6000
4	335	754	1340	2085	3000
6	224	503	894	1390	2000
8	168	377	670	1040	1500
10	134	302	536	833	1200
12	112	251	447	694	1000
14	96	215	383	595	857
16	84	189	336	521	750
18	74·5	167	298	463	667
20	67	151	268	417	600
22	61	137	244	379	545
24	56	126	224	347	500
26	51·5	116	206	321	462
28	48	108	192	298	428
30	44·7	100	178	278	400
32	41·8	94	168	261	375
34	39·4	88·5	158	245	353
36	37·2	83·6	149	231	334
38	35·3	79·5	141	219	316
40	33·5	75·4	134	208	300
42	31·9	71·8	128	198	286
44	30·5	68·5	122	190	273
46	29·2	65·6	117	181	261
48	28	62·8	112	173	250
50	26·8	60·3	107	167	240
52	25·8	58	103	160	231
54	24·8	55·8	99	154	222
56	24	53·8	96	149	214
58	23·1	52	92·4	144	207
60	22·4	50·2	89·3	139	200
62	21·6	48·6	86·4	134	194
64	21	47·2	83·7	130	188
66	20·3	45·7	81·2	126	182
68	19·7	44·4	78·8	123	176
70	19·2	43	76·6	119	171
72	18·6	41·9	74·4	116	167
74	18·1	40·7	72·4	113	162
76	17·7	39·7	70·6	110	158
78	17·2	38·7	68·7	107	154
80	16·8	37·7	67	104	150
82	16·3	36·8	65·2	102	146
84	16	35·9	63·7	99	143
86	15·6	35·1	62·3	97	139
88	15·2	34·3	60·8	95	136
90	14·9	33·5	59·6	93	133
92	14·6	32·8	58·3	91	130
94	14·3	32·1	57	89	128
96	14	31·4	55·8	87	125
98	13·7	30·8	54·7	85	122
100	13·4	30·2	53·6	83	120

TABLE II.—CORRESPONDING STOPPING TIMES

Brake Efficiency per cent. Meter Reading	*Time to Stop in Seconds*					*Rate of Retardation*	
	From 20 m.p.h.	*From 30 m.p.h.*	*From 40 m.p.h.*	*From 50 m.p.h.*	*From 60 m.p.h.*	*Feet per sec. per sec.*	*M.P.H. per sec.*
2	45·7	68·5	91·4	114	136	·64	·44
4	22·8	34·2	45·6	57	68	1·29	·88
6	15·3	23	30·6	38	46	1·93	1·32
8	11·4	17·2	22·9	28	34	2·57	1·76
10	9·1	13·7	18·3	23	27	3·22	2·2
12	7·6	11·5	15·3	19	23	3·86	2·64
14	6·6	9·8	13·1	16	20	4·5	3·08
16	5·7	8·6	11·5	14	17	5·15	3·52
18	5·1	7·6	10·2	13	15	5·8	3·96
20	4·6	6·8	9·1	11	14	6·44	4·4
22	4·2	6·2	8·3	10	12	7·08	4·84
24	3·8	5·7	7·6	9·5	11	7·72	5·28
26	3·5	5·3	7	8·8	11	8·36	5·72
28	3·3	4·9	6·5	8·1	9·8	9	6·16
30	3	4·6	6	7·6	9·1	9·65	6·6
32	2·9	4·3	5·7	7·1	8·5	10·3	7·04
34	2·7	4	5·4	6·7	8	10·9	7·47
36	2·5	3·8	5·1	6·3	7·6	11·6	7·92
38	2·4	3·6	4·8	6	7·2	12·2	8·36
40	2·3	3·4	4·6	5·7	6·8	12·9	8·8
42	2·2	3·3	4·4	5·4	6·5	13·5	9·24
44	2·1	3·1	4·2	5·2	6·2	14·2	9·67
46	2	3	4	4·9	5·9	14·8	10·1
48	1·9	2·9	3·8	4·7	5·7	15·5	10·56
50	1·8	2·7	3·7	4·6	5·5	16·1	11
52	1·8	2·6	3·5	4·4	5·3	16·8	11·45
54	1·7	2·5	3·4	4·2	5·1	17·4	11·9
56	1·6	2·5	3·3	4·1	4·9	18	12·3
58	1·6	2·4	3·2	3·9	4·7	18·7	12·8
60	1·5	2·3	3·1	3·8	4·6	19·3	13·2
62	1·5	2·2	3	3·7	4·4	20	13·6
64	1·4	2·1	2·9	3·6	4·3	20·6	14·1
66	1·4	2·1	2·8	3·5	4·1	21·2	14·5
68	1·3	2	2·7	3·3	4	21·9	15
70	1·3	2	2·6	3·2	3·9	22·5	15·4
72	1·3	1·9	2·5	3·2	3·8	23·2	15·8
74	1·2	1·9	2·5	3·1	3·7	23·8	16·3
76	1·2	1·8	2·4	3	3·6	24·4	16·7
78	1·2	1·8	2·3	2·9	3·5	25·1	17·2
80	1·1	1·7	2·3	2·8	3·4	25·7	17·6
82	1·1	1·7	2·2	2·8	3·3	26·4	18
84	1·1	1·6	2·2	2·7	3·2	27·1	18·5
86	1·1	1·6	2·1	2·6	3·2	27·7	18·9
88	1·1	1·6	2·1	2·6	3·1	28·3	19·4
90	1	1·5	2	2·5	3	29	19·8
92	1	1·5	2	2·5	3	29·6	20·2
94	1	1·5	2	2·4	2·9	30·2	20·7
96	1	1·4	1·9	2·4	2·8	30·9	21·1
98	·9	1·4	1·9	2·3	2·8	31·6	21·6
100	·9	1·4	1·8	2·3	2·7	32·2	22

rotating dial. The instrument is clamped in this position, and no connection is required with any part of the vehicle's mechanism.

Making the Road Test

In order to obtain a test reading, the instrument control is turned to " test," the vehicle driven up to any speed above 15 m.p.h., and the brakes applied. There is no need to observe the reading, as the scale is automatically held at the maximum obtained. The reading can therefore be noted after each individual brake application, and by turning the control to " free " and then back to " test," the dial is returned to zero and the instrument is ready to record another brake application. Generally speaking, brake testing is carried out on approximately level roads, but this type of inertia instrument can be equally satisfactorily used on a gradient, the instrument still recording correctly under such conditions.

Other Instruments

With regard to the similar inertia instruments arranged as a mass of liquid in glass tubing, the principle on which they operate is exactly similar to the pendulum type, but suffers under the disadvantage that the reading of the liquid level must be carried out during the actual brake application, and it is therefore almost impossible to use this type single-handed.

There are, of course, more elaborate types of instruments in use for road brake testing, but these are confined to the research departments of vehicle and brake-lining manufacturers and some technical institutions. These types of instruments frequently consist of a cycle wheel of accurately measured circumference mounted on a trailing arm which can be attached to the vehicle to be tested. A light drive is taken up this arm and serves to propel paper strip at a speed proportional to the vehicle's speed while a mark is made on the paper indicating the precise point at which the brakes were applied and a similar mark when the vehicle comes to rest—the distance between these marks represents the stopping-distance to a predetermined scale. This measurement would, of course, be useless without an accurate record of the initial speed, and this is obtained by time markings controlled from a scientifically accurate clock.

We are indebted to Messrs. Ferodo, Ltd., for the information upon which the above article is based.

THE BEDFORD CHASSIS

K, M, AND O MODELS

A SECTIONAL view of the rear axle and rear hub of Model K truck is shown in Fig. 1.

The axle housing is a built-up assembly consisting of large-diameter steel tubes pressed into a central differential carrier of cast steel, and located by dowels. (Side tubes cannot be serviced separately, owing to pressure required to press them into the differential carrier.)

The final drive consists of spiral bevel gears, the pinion being straddle-mounted between a single-row roller bearing at its inner end and a double-row ball bearing located between the pinion and the propeller-shaft coupling flange. Pinion adjustment is controlled by shims.

The pinion is offset $1\frac{7}{16}$ in. to the right-hand side of the chassis centre-line, in order to equalise the loading on the differential bearings, but the axle shafts are of equal length and interchangeable. A thrust-pad limits spiral-drive gear deflection under heavy loading.

The differential assembly is mounted between two ball bearings housed in the differential carrier and located by threaded locking rings.

In Model M, the axle housing, final drive, and differential assembly are similar to the K type, the main difference being that for the M-type rear axle the axle housing tubes are formed to support the wheel hub bearings.

The general design of Model O is similar to the M-type axle, but is of heavier construction to suit the wider track and higher loading. The pinion is offset $1\frac{1}{2}$ in. to the right-hand side of the chassis centre-line, and the differential assembly is mounted between tapered roller bearings.

Removal of Differential Assembly—Model K

To remove the differential case and spiral-drive gear assembly, the following operations must be carried out:

Jack up the rear of the vehicle and remove the wheels, hubs, and axle-shaft key.

Next remove the ten setscrews and lock washers which attach the pressed-steel oil deflector encircling the axle shafts to the axle casing.

Remove the "perfect" oil seal and bearing retaining plate, and withdraw the axle shaft complete with bearing.

Place an oil tray under the centre of the axle, then remove the nine setscrews and one nut and lock washer which attach the axle-housing cover, and remove the cover.

Mark the differential carrier caps to ensure that they are refitted to the same side.

Remove the four large bolts and lock washers which retain the differential carrier caps.

Remove the caps and lift out the differential case and spiral-drive gear assembly.

Removal of Differential Assembly—Models M and O

Jack up the rear of the vehicle for easy access.

Remove the ten nuts and lock washers at the outer extremity of each rear hub and draw out the axle shaft approximately 1 ft., so that the shaft clears the side gear splines.

The remaining operations involved in removing the differential cage and ring-gear assembly are the same as those already described for the K model.

ALL MODELS

To Replace Differential Assembly

Replacement of the differential assembly can be effected by reversing the operations given for removal, noting the following points :

The rear axle on the 3/4-ton and 5-ton models should always be refilled with an extreme-pressure lubricant.

Removal of Spiral-drive Pinion

Remove the differential case and spiral-drive gear assembly as previously described.

Disconnect the rear universal joint from the flange of the bevel pinion, and the hand-brake operating rods from the bell-crank lever end.

Remove the setscrews and the lock washers from the pinion cover. Then, by applying light blows with a lead hammer to the inner end of the pinion, drive out the pinion, together with the universal joint flange and the pinion cover and oil-seal assembly, towards the front end of the axle casing.

To Replace Spiral-drive Pinion

Reverse the operations given for removal, particularly noting the following points :

The correct shimming of the pinion is imperative. Therefore, providing no parts have been renewed, the same number of paper shims between the front cover and the differential carrier face and the metal shims at the rear of the thrust-bearing outer race must be replaced as removed.

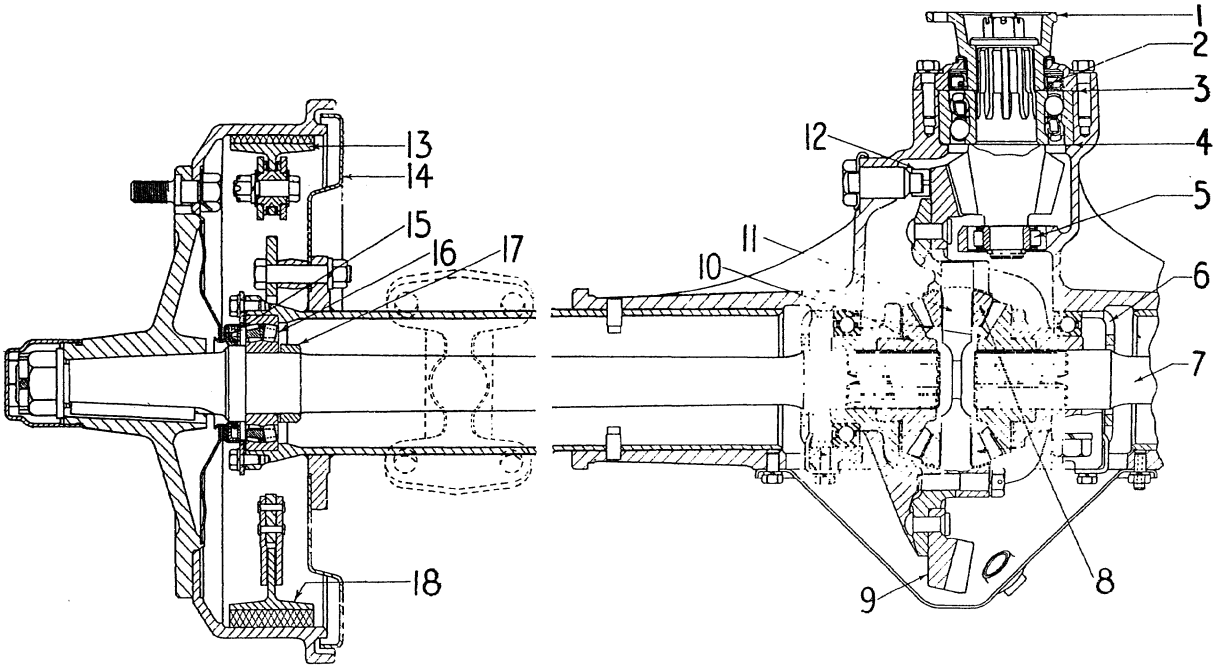


Fig. 1.—Sectional view of rear axle and rear hub—model K

1. Universal joint flange.
2. Oil seal.
3. Pinion adjustment washers.
4. Pinion adjustment washers.
5. Pinion support bearing.
6. Crown wheel adjusting ring.
7. Axle shaft.
8. Planet wheel.
9. Crown wheel.
10. Sun wheels.
11. Planet pinion spindle.
12. Crown wheel thrust pad.
13. Brake shoe.
14. Brake flange plate.
15. Oil seal.
16. Hub bearing.
17. Bearing locking ring.
18. Brake shoe.

These shims are ·005 in. and ·010 in. in thickness, and it is always necessary to insert paper shims between the front cover and the differential-carrier front face to a thickness of ·010 in. more than the thickness of the metal shims. This allows for compression of the paper shims and ensures an effective oil seal.

Removal of Rear-Axle Assembly Complete

Jack up the rear of the vehicle and remove the road wheels. Disconnect the rear universal joint from the flange of the bevel pinion.

Disconnect the hydraulic-brake flexible tube at the point of connection to the copper tubing, which runs from a bracket bolted to the chassis side member to the union on the Lockheed servo unit master cylinder.

Disconnect the hand-brake cable from the bell-crank lever by slackening the locknut and removing the setscrew which secures the "eye" end of the cable to the bell-crank-lever ball.

Place a jack underneath the centre of the axle, so as to carry the weight of the axle assembly, and remove the U-bolt nuts and the U-bolts. Lower the axle on the jack sufficiently to allow the jack, together with the axle, to be drawn out from under the vehicle.

To Replace Rear Axle

Replacement of the rear axle can be effected by reversing the operations given for removal, noting the following points.

It is essential that the master cylinder of the brake system is topped up, and that bleeding of the brake system is carried out as required by Lockheed hydraulic brakes provided with vacuum servo cylinder assistance.

The rear axle on the ¾-ton and 5-ton models should always be refilled with an extreme-pressure lubricant.

Spiral-drive Gear

When it becomes necessary to fit a new spiral-drive gear, it is necessary to warm the gear on a hot-plate just sufficiently to allow it to be dropped into position on the differential cage register. Before the gear is allowed to cool down, the rivet holes must be lined up and the gear bolted into position on the cage in four places, so that the riveting can be carried out. Cold rivets must be used.

The backlash between the spiral-drive pinion and the spiral-drive gear should be not less than ·006 in. and not more than ·010 in.

BRAKES

Lockheed hydraulic brakes, employing a tandem master cylinder which prevents any possibility of complete foot-brake failure in the event of leakage from front or rear pipe lines, are fitted on all models.

With the exception of the model K, which is not provided with servo

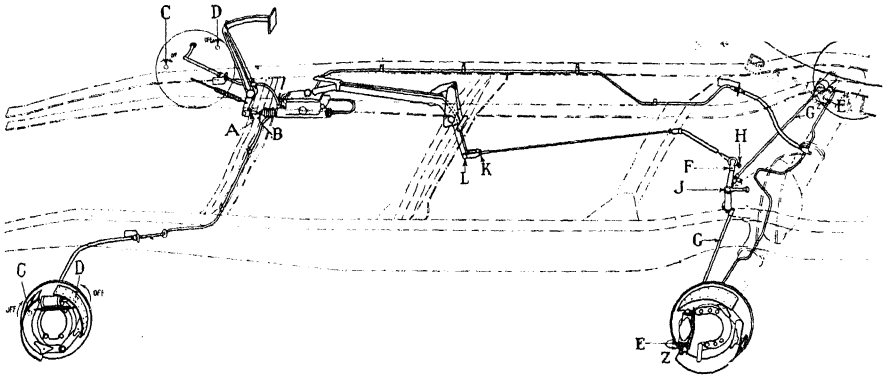


Fig. 2.—BRAKE ADJUSTMENT CHART—MODEL K

assistance, the vacuum servo cylinder is mounted as a unit with the Lockheed cylinder, and is coupled by means of enclosed linkage forming part of the combined assembly. The Lockheed-servo unit assembly is bolted to the chassis frame just behind the foot-brake pedal.

On the front brakes the wheel cylinders are enclosed by the brake drum in a conventional manner, as on other Lockheed systems ; the rear-wheel cylinders, however, are mounted externally to obtain maximum cooling.

Particulars of Lockheed and Lockheed-servo brake systems will be found in Vol. I, pp. 284–304.

Foot-brake Adjustment

Each front-brake shoe is provided with a cam-type adjuster operated from the outside of the brake backplate by a hexagon-headed bolt (*see* Figs. 2 and 3).

Jack up the front wheel and turn the cam nuts *C* & *D* to the fully " off " position. Then turn the cam nut *C* in the direction of the arrow, until the front-brake shoe rubs slightly on the inside of the drum. Slacken back sufficiently to ensure that the drums are perfectly free.

Repeat the operation with the rear-cam nut.

It is very important that each front wheel rotates freely without the slightest drag following adjustment.

To adjust the rear brakes, jack up the rear wheels, making certain that the hand-brake lever is in the fully " off " position. Remove the rubber flaps underneath the wheel cylinder, which gives access to the brake-shoe adjusting wheel. Turn the adjusting wheel *E* in the direction of arrow *Z* until it is not possible to turn it any farther.

Apply heavy pressure to the foot-brake pedal, to centralise the shoes in relation to the drums. (This centralisation is automatic through the

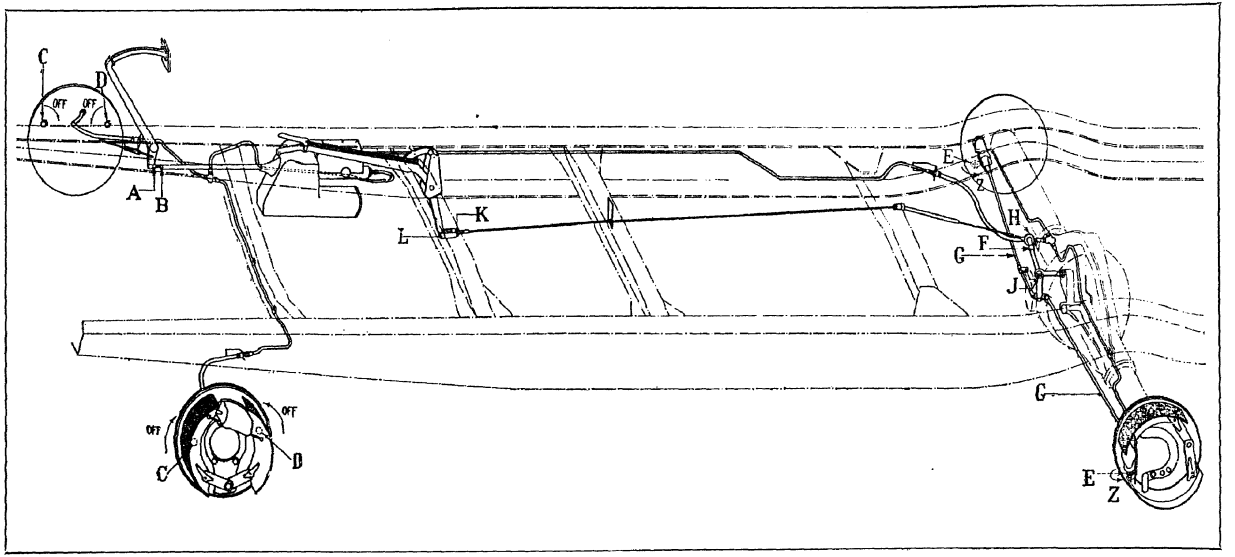


Fig. 3.—BRAKE ADJUSTMENT CHART—MODELS M AND O

A. Clevis pin.
B. Locknut.
C. and D. Cam nuts.
E. Adjusting wheel.
F. Lever.
G. Hand-brake side rods.
H. Setscrew.
J. Bell-crank-lever fulcrum pin steady.
K. Locknut.
L. Clevis pin.

bisector, for particulars of which *see* Vol. I, p. 242). Again turn the adjusting wheel as far as possible. Slacken the adjustment back approximately three notches, or until the road wheels rotate freely.

Always replace the rubber flaps.

Hand-brake Adjustment

Do not attempt to adjust the hand-brake independently. The adjustment for the rear-brake shoes given under "Foot-brake Adjustment" serves for both foot-brake and hand-brake adjustment, unless any part of the hand-brake mechanism has been dismantled.

Except in the case of accident or previous incorrect setting, the hand-brake mechanism should not be disturbed. Should cases arise, however, where resetting is necessary, proceed as follows, with reference to Figs. 2 and 3.

Release the hand-brake lever to the fully "off" position, and remove the clevis pins (one at either end) from the hand-brake side rods *G*. Remove the rubber flap which gives access to the adjusting wheel, and tighten the wheel *E* as far as possible.

Slacken back the locknut on the bell-crank-lever fulcrum pin steady *J*, and affix the bell-crank lever setting bracket. Slacken the locknut at the wheel-cylinder end of the hand-brake side rods, and adjust the rods so that the clevis pins securing the rods to the bell-crank-lever mechanism may be inserted. Tighten up the hand-brake side rod locknuts.

Next slacken back the locknut *K*. Remove the clevis pin *L* and adjust the clevis end until the slack in the cable is equal to two-thirds of the diameter of the clevis-pin hole.

Replace the clevis pin and tighten the locknut. Make certain that setscrew *H* is seating in ball end of lever *F*.

Adjust the rear-brake shoes as described under "Foot-brake Adjustment." Remove the bell-crank-lever setting bracket and thoroughly tighten the locknut on the bell-crank-lever fulcrum pin steady *J*.

Foot-brake-pedal Adjustment

It is important that the foot-brake pedal has $\frac{1}{4}$-in. free movement. To adjust the pedal for clearance, slacken back locknut *B*, remove the clevis pin at the front end of rod *A*, and turn the yoke end until the requisite clearance is obtained. Replace clevis pin and tighten locknut *B*.

JCV 10/12-CWT. VAN

The design of the JCV 10/12 independent front-wheel suspension is as follows:

The torsion shaft and tube assembly, which constitutes the main front-spring component, interacts with a pre-compressed coil spring

acting upon a toggle lever, and double-acting hydraulic shock absorbers which eliminate road shocks in both the bump and rebound direction.

Servicing procedure for a similar system of independent front-wheel suspension is described in Vol. III, pp. 62–70, under the heading "Vauxhall Independent Suspension Systems."

Front-end Height

To check the standing height of the front of the vehicle without dismantling, measure the distance from the bottom edge of the brake-flange plate to the head of the foremost bolt attaching the rebound bumper bracket to the steering knuckle. This dimension should be $1\frac{11}{32}$ in. plus or minus $\frac{3}{16}$ in.

If readjustment is necessary, proceed as described below.

In order to remove the torsion shaft and tube assembly from the housing without effort, it is necessary to adjust the position of the carrier arm so that there is no torsion (or twist) in the shaft and tube. Remove the rebound bumper and bracket and affix Britool Jig No. 899 to the bottom of the spring housing, then turn the adjusting screw until the distance between the edge of the jig farthest away from the carrier arm and the face of the web against which the adjusting screw contacts measures $1\frac{3}{4}$ in. plus or minus $\frac{1}{8}$ in. This brings the carrier arm to the no-torsion position.

Adjustment of Vehicle Front-end Height

Whenever a torsion shaft and tube assembly has been fitted, a check should be made to determine whether the front of the car is standing at its correct height.

With a weight equivalent to two persons 10–12 st. in weight in the front compartment of the vehicle, measure the distance from the bottom edge of Britool Jig. No. 899 to the bottom edge of the brake-flange plate. This should be $2\frac{1}{2}$ in. plus or minus $\frac{1}{8}$ in.

When checking the above measurement, slacken well back the jig-adjusting screw, and bounce the front of the vehicle lightly to ensure that friction in the suspension units is not giving a false reading.

It is possible that the measurement may not come within these limits, and in view of this a vernier adjustment is provided by the relationship between the splines in the torsion shaft and the holes in the torsion-tube flange, there being forty-nine and eight respectively.

If the vehicle is too low on the side that has been disturbed, it must be raised once more and the nuts and lock washers removed from the flange-retaining studs. Bring the carrier arm to the "No-torsion" position, and extract torsion-shaft assembly clear of the splines.

Rotate the tube nearly one-eighth of a turn (six splines on the shaft) in the required direction, according to which unit is being treated.

Note Carefully: To raise the front of the vehicle, the torsion-shaft assembly must be rotated in a clockwise direction for the nearside unit

and in an anti-clockwise direction for the offside unit when facing the flange of the assembly concerned. To lower, turn the torsion-shaft assembly in the reverse direction.

Push the shaft gently into the beginning of the splines and tighten the jig-adjusting screw until the holes in the flange of the torsion tube line up with the studs, when the tube can then be pushed right home. *Do not use force during this operation.*

Lower the vehicle and check the dimension to see that front-end height is correct.

If the vehicle is too high on one side, bring the carrier arm to the "No-torsion" position. Turn the tube assembly nearly one-eighth of a turn (six splines on the shaft) in the reverse direction to that for raising the front of the vehicle, push the torsion shaft into the beginning of the splines, and slacken the jig-adjusting screw until the holes in the flange of the tube line up with the studs of the housing. The torsion shaft and the tube assembly should then be pushed right home.

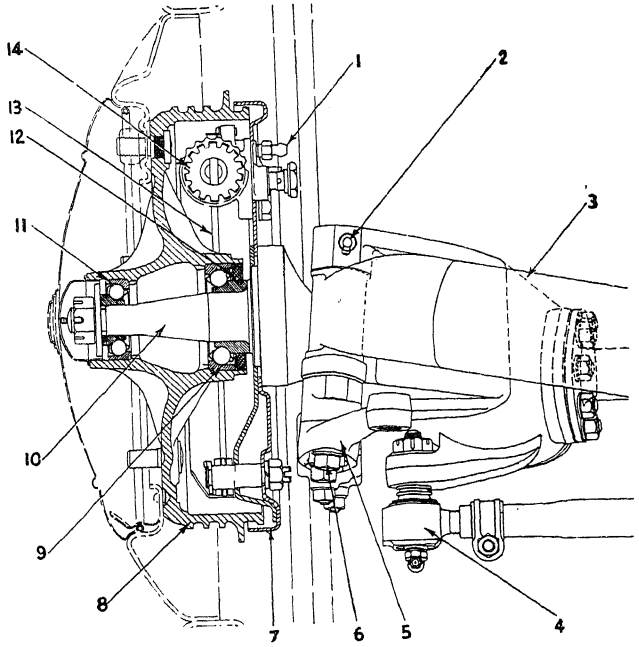


Fig. 4.—SECTIONED FRONT HUB AND BRAKE GEAR

1 Hydraulic brake bleeder.
Pivot pin lubrication nipple.
3 Pivot pin support member (front axle).
4. Tie road joint.
5. Steering arm.
6. Steering arm foremost bolt.
7. Brake flange plate.
8. Brake drum.
9. Front hub ball race (inner).
10. Wheel carrier arm stub axle.
11. Front hub ball race (outer).
12. Oil seal assembly.
13. Front brake shoe.
14. Brake adjusting screw.

Having obtained the correct adjustment for height, remove the jig, replace the steering arm or rebound bumper bracket, lower the vehicle, and replace and tighten the nuts and washers which secure the tube flange.

Refill units with fresh shock-absorber oil.

Steering Arm and Connections

The pivot-pin bronze bushes are fully floating, and a ball thrust-bearing is interposed between the lower face of the pivot-pin boss of the axle beam and the steering knuckle. Lift of the steering knuckle is controlled to provide a clearance of ·003 in. maximum, by shims ·005 in. and ·010 in. thick which are fitted on the upper face of the pivot-pin boss.

The self-adjusting spring-loaded ball joints are serviced only as complete assemblies. In the event of excessive wear taking place, it will be necessary to renew the whole assembly.

Removal and Replacement of Steering Joints

To remove the ball joint for renewal, remove the cotter pin and partly unscrew the nut which secures the ball joint, then, by lightly tapping the nut with a copper hammer, the tapered shank portion of the ball joint can be driven out.

Slacken off the clamp-bolt which secures the ball joint to either the tie-rod or connecting rod, and unscrew the ball joint from the threaded end of the rod.

To replace, reverse the operations given for removal.

Front-wheel Alignment

Front-wheel alignment is measured in the usual way at the wheel rims, in line with the centre of the hubs, and with the wheel straight ahead it should be noted that there is *no* " toe-in " allowance. To enable this condition to be maintained, adjustment is provided at each end of the tie-rod by means of right-hand and left-hand threads, screwing into the tie-rod ends.

Adjustment for End Float in Steering-worm Shaft

The adjusting nut of the ball race controlling end float of the worm shaft is integral with the top cone of the bearing, and is secured by a locknut.

With the front of the vehicle jacked up, the adjusting nut should be tightened down gently, until a slight load is felt on the steering wheel when turned, after which the adjusting nut should be slackened back slightly until the steering wheel feels free. Finally, holding the adjusting nut in position, retighten the locknut.

Propeller Shaft and Universal Joints

The drive is transmitted from the gearbox to the rear axle by an open tubular propeller shaft, embodying two Hardy Spicer needle-roller-type universal joints. These joints are packed with special non-separating grease and require no further attention. An oil-gun nipple is provided for lubricating the splines at the forward end of the shaft.

The universal joints at each end of the shaft are attached by four

high-tensile steel bolts, slotted nuts, and split-pins to coupling flanges fixed respectively to the rear of the gearbox mainshaft and the forward end of the bevel-pinion shaft.

To Remove and Replace

The removal and replacement of the shaft entails the removal and replacement of the eight bolts and nuts mentioned above.

If for any reason the front universal joint is removed from the splines of the propeller shaft, it is essential that the joint is replaced to give correct relationship with the rear universal joint. This is obtained by lining up the lugs of the *flanged* yoke on the front universal joint with the lugs of the *flanged* yoke on the rear universal joint.

This position is also indicated by two arrow marks pointing towards each other and in line, one being on the main body of the propeller shaft near the splined end, and the other on the outside of the splined portion of the front universal joint.

Rear Axle

The rear axle is of the semi-floating type, having spiral-bevel final drive gears. The differential is slightly offset, and necessitates the use of axle shafts of different lengths ; consequently the right- and left-hand shafts are not interchangeable.

For additional information on the repair of this type of axle, the reader is referred to " Repair Notes on Vauxhall Cars," p. 169, Vol. III.

Removing Differential Carrier Assembly from Vehicle

To remove the differential carrier assembly from the vehicle, the following operations must be performed :

Having jacked up the vehicle sufficiently high for the rear wheels to clear the ground, remove the wheels and hubs. Provision is made for a hub drag by means of an external thread on the centre boss of the hub.

Disconnect the hydraulic-brake pipe line at the unions on each rear-brake flange plate, and remove the four bolts which secure each flange plate to the rear-axle casing. Lift away the flange plates as far as is allowed by the movement of the hand-brake cable, and place by the side of the vehicle.

The axle shafts can now be withdrawn sufficiently to clear the splines in the side gears of the differential assembly.

Remove the four bolts and slotted nuts securing the rear univeral joint of the propeller shaft to the flange of the differential unit.

Release the eight nuts which secure the differential assembly to the rear-axle casing, and lift away the assembly, taking care not to damage the threads of the securing studs retained in the rear-axle casing.

Removing Rear-axle Assembly Complete from Vehicle

To remove the rear-axle assembly complete from the vehicle, a sequence of operations slightly different from those previously described will have to be undertaken.

Jack up the rear of the vehicle and remove the road wheels.

Disconnect the rear universal joint of the propeller shaft from the flange of the differential unit.

Disconnect the hydraulic-brake pipe line at the front end of the flexible tube which carries the brake fluid from the end of the copper tubing underneath the body to the copper tubing slipped to the back-axle casing.

Remove the hand-brake cable outer casings from the securing clips on the chassis frame.

Remove the two hand-brake cables from the hand-brake relay lever by releasing the single clevis pin which secures the two cable-yoke ends to the lever. Unscrew the nuts from the four U-bolts connecting the rear axle to the springs, and remove the U-bolts.

The axle is now free and can be lifted out sideways over the springs, taking care not to damage the brake flange plates.

Footbrake Adjustment

As wear occurs on the brake linings the amount of travel on the foot pedal increases, until the pedal will be forced nearly to the floorboards on heavy application of the brakes. When this occurs the shoes should be expanded by adjusting the sleeves *D*.

Jack up each wheel in turn and, with a screwdriver, remove the wheel-hub cover. This will reveal a hole in each brake drum which gives access to the adjusting sleeves *D*.

Using a screwdriver against the serrations, turn the right-hand sleeve (as viewed by the operator) of each brake upwards until the shoe just touches the drum, then back off four notches.

Turn the left-hand sleeve (as viewed by the operator) downwards until the shoe touches the drum, and then back off four notches, as in the previous case.

Hand-brake Adjustment

Whenever the rear-brake shoes are adjusted, the handbrake should be checked for operation and adjusted to suit.

Do not adjust the hand-brake without first taking up the adjusting sleeves D *of the rear brakes.*

Having taken up the adjusting sleeves *D* of the rear brakes, slacken off the locknut which secures the clevis end *A* at the end of the hand-brake primary cable. Remove the clevis pin from the clevis end and relay lever, and screw the clevis end along the thread until, with the clevis pin temporarily inserted, the hand-brake lever can be pulled on four notches without using undue force.

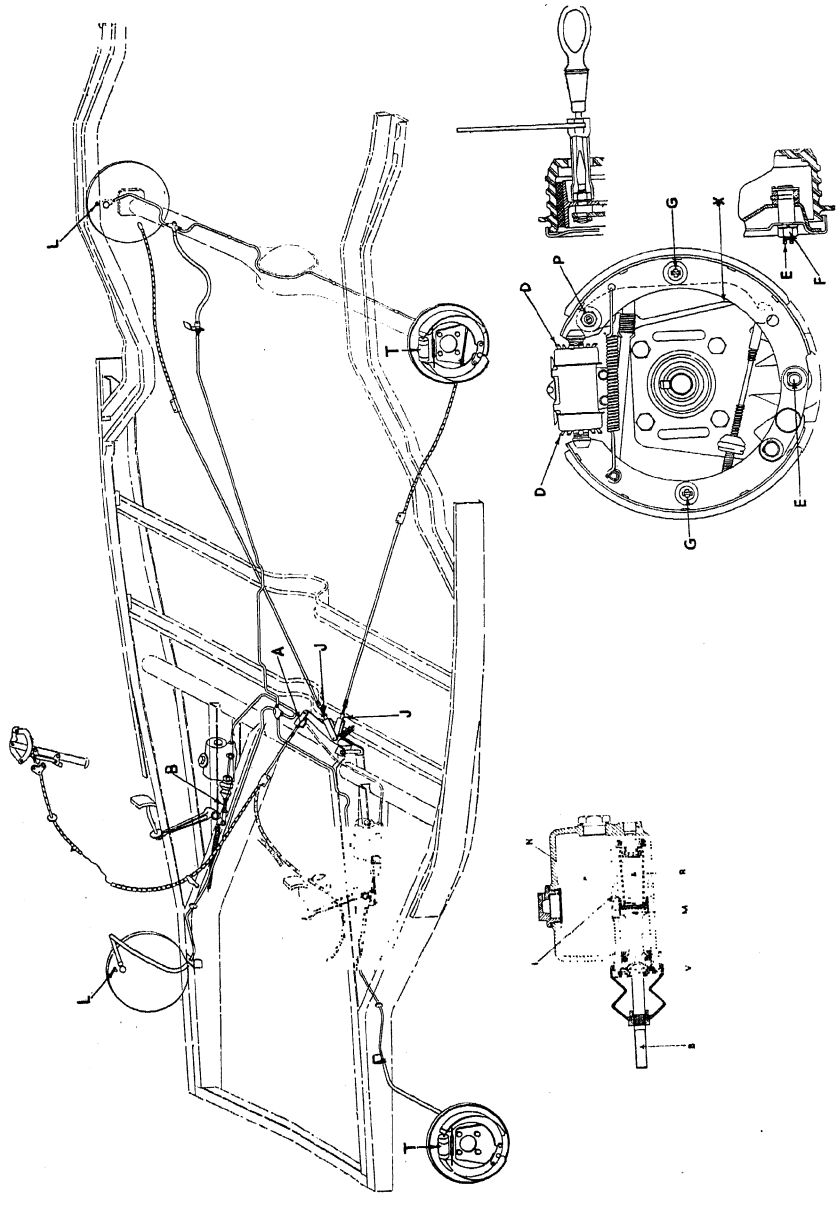


Fig. 5.—BRAKE ADJUSTMENT CHART—JCV MODEL

Re-insert the split-cotter in the clevis pin, and retighten the locknut which secures the clevis end *A*.

If the braking is uneven when the hand-brake is applied, balance of the brakes can be obtained by releasing the locknuts which secure the adjusting sleeves *J* on the hand-brake rear cables. Adjust the sleeves *J* until equal braking is obtained on both wheels, and securely tighten the locknuts retaining the sleeves *J* in position.

Finally release the hand-brake lever to the fully " off " position and, with the rear of the vehicle still jacked up, rotate the rear wheels to ensure that the brakes are not rubbing.

Hand-brake Adjustment after Mileage

After considerable mileage, the hand-brake operating lever in the rear hub will reach the limit of its travel, necessitating attention to an additional hand-brake adjustment inside the rear hub. To carry out this adjustment, jack up the rear of the vehicle and remove the rear wheels. Release the hand-brake lever to its fully " off " position.

Slacken the clevis end *A* of the hand-brake primary cable, also the cable-adjusting sleeves *J*. Adjust the clevis end *A* until the centre of the clevis pin is $8\frac{1}{4}$ in. from the centre of the tubular cross-member, when the relay lever is pulled to the rear of the vehicle, to take up any slackness.

Adjust the sleeves *J* on the hand-brake rear cables so as to take out any excessive slackness, and then pull the hand-brake lever on four notches.

Slacken off the locknut *P* in each rear hub, using the box spanner provided in the tool-kit. Insert a screwdriver down the centre of the box spanner into the slot provided, and rotate each bolt until the brake show makes contact with the drum, and a heavy drag is felt when turning each rear drum.

Tighten the locknuts *P*, and replace the wheels and hub covers. If the braking is uneven when the hand-brake is applied, balance of the brakes can be obtained by releasing the locknuts which secure the adjusting sleeves *J* on the hand-brake rear cables. Adjust the sleeves *J* (letting out the cable of the brake which binds hardest) until equal braking is obtained on both rear wheels. Retighten the locknuts.

The hand-brake operating cables are provided with greasers and should be lubricated every four thousand miles.

The hand-brake rear cables should be adjusted only for the purpose of balancing the rear brake after the major operation has been carried out, and *not* for taking up the adjustment.

Removal of Brake Shoes

When it becomes necessary to remove the brake shoes for examination or relining, this may be done without disturbing any part of the fluid system, the procedure being as follows :

Jack up the vehicle and remove the road wheels ; remove the combined hub and brake drum if dealing with the front brake, or in the case of the rear brake, remove the hub and drum from the taper of the axle shaft.

N.B.—Whenever a brake drum is removed for any reason, or a brake-shoe return spring is disconnected, care must be taken that the brake pedal is not depressed, as this would cause the pistons of the partially dismantled brake to be forced out of the cylinders, with the result that fluid will be lost, necessitating bleeding the system.

Disconnect the brake-shoe return spring and remove the shoe-guide springs and cups *G* by depressing the latter, and turning through an angle of 90°. Prise up and remove the lock washer from the pivot pin *E*, when the two brake shoes, together with the servo links attached to the leading shoe, can be removed.

In the case of the rear brakes, an additional operation is required. The nut *P* must be removed, thus releasing the trailing shoe from the hand-brake operating lever, which may be left in position.

N.B.—With the shoes removed one vitally important point must be realised before relining is undertaken. The balance of the brakes is dependent solely upon the coefficient of friction between the brake lining and brake drum, and since the fluid method of operation allows full compensation, it is essential that the same lining material be used for each brake shoe. Under no circumstances allow the linings to come in contact with oil or grease. Do not even touch the friction surface with the hands. Do not alter the existing chamfer at the ends of the linings.

Failure to comply with these instructions will lead to persistent trouble due to unbalanced braking.

The operations involved in relining the shoes follow the usual practice, but every care must be taken not to get grease on the friction surface.

Brake-shoe Reassembly

When refitting the brake shoes the sequence of operations is reversed, and the brakes reset as described on p. 506 under "Footbrake Adjustment."

Resetting the Brake System

Except in the case of accident or due to previous incorrect setting, the brake system should not be disturbed, but should cases arise where resetting is necessary, proceed as follows :

Adjust the foot-pedal push-rod *B* by slackening the locknut and adjusting the push-rod, so that there is $\frac{1}{2}$ in. free movement at the foot-brake pedal when it is in the fully "off" position, afterwards tightening the locknut which secures the push-rod.

This clearance or free travel is essential in order to allow the piston *M* in the master cylinder to return fully against its stop *V* and uncover the by-pass port *I*. If the return of the pedal is restricted, resulting in the

by-pass port being covered by the piston, the brakes will not release properly.

Set the hand-brake lever in the fully "off" position. Jack up the wheels and set the adjusting sleeves *D* to bring the brake shoes as close to the drums as possible. Adjust the hand-brake primary and rear cables to give the dimension of $8\frac{1}{4}$ in. between the clevis pin of the relay lever and the centre of the tubular cross-member, as described, taking care to ensure that the brake drums are not rubbing on the liners when adjustment is completed.

ADAPTING EXISTING BODYWORK FOR EMERGENCY USE

By H. J. BUTLER

CAREFUL attention to repairs and overhauling is of particular importance in war-time, because by this means the useful life of existing vehicles, which are difficult to replace, is extended. Also, vehicles, both new and already in service, are required to carry a different kind of load from that for which they were first designed. Consequently these vehicles require some structural alteration, or additional equipment, in order that they may be better adapted for the new condition of service.

Alterations to Bodywork

This emergency aspect of repair work consists chiefly of alterations to the bodywork, and ranges from a simple extension of the sides of a lorry up to the conversion of a luxuriously appointed coach into a capacious delivery van.

Using Old Yet Sound Material

In all such conversion jobs, economy of material should be carefully studied, because not only is the supply controlled and deliveries often delayed, but it is also more expensive than formerly. When new timber is not available, use should be made of the sound timber of second-hand bodywork. Timber does not deteriorate with age if it has been well protected by paint or other preservative. For similar reasons, the ironing up and panelling of the body may often be partly accomplished with material from an old body.

INCREASING HEIGHT OF LORRY SIDES

A drop-sided lorry may be required to carry farm produce or other bulky load, and its capacity must be increased. This may be done in various ways. The height of the body sides is approximately doubled by means of a superstructure consisting of uprights made from 3-in. by 1-in. deal battens. On the inside of these uprights are screwed lengthwise battens of 3-in. by $\frac{3}{4}$-in. deal, except for the bottom batten, which is 5 in. wide. This batten rests on top of the body side, as shown in Fig. 1.

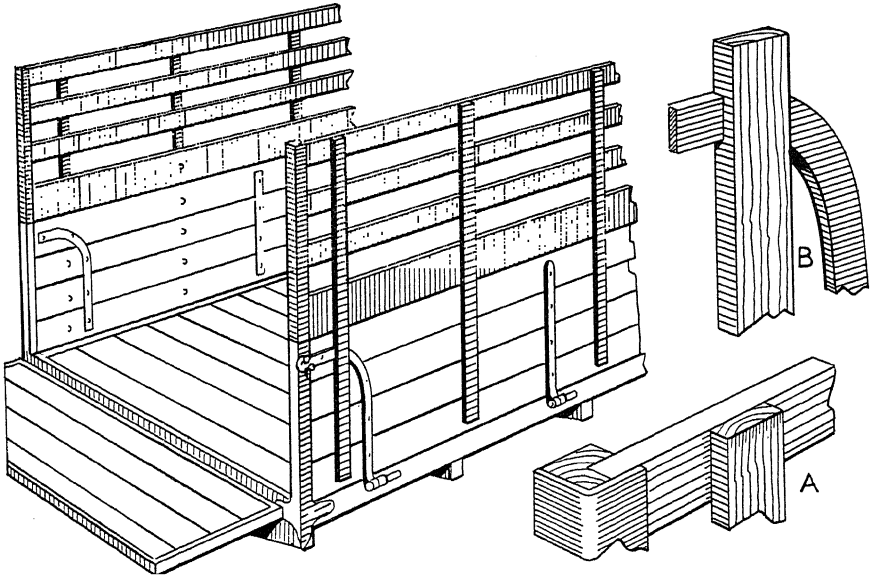


Fig. 1.—DROP-SIDED LORRY WITH THE HEIGHT OF THE SIDES INCREASED

A. End of lengthwise slat let into wood-filled angle-iron post. B. End upright recessed at the back for passage of hinge iron.

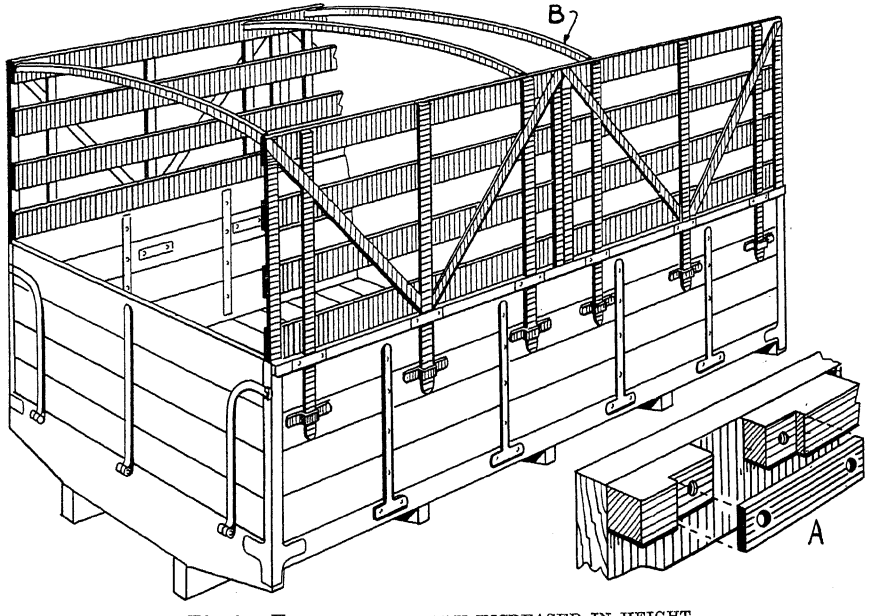


Fig. 2.—FIXED-SIDED LORRY INCREASED IN HEIGHT

Repairs to the Top Board

If the lorry has been in service some time, the top board of the drop-side may be worn, especially if it is not protected by a half-round or channel-section wearing plate. If badly worn or split, it should be renewed. The board is removed by releasing it from the top bolts which pass through the hinge-iron and the corresponding inside plate of $\frac{1}{8}$-in. mild steel, which provides a firm foundation against which the heads of the bolts are tightened.

Hind-corner Stanchions

The lorry usually has hind-corner stanchions, the feet of which are secured to the bottom frame of the lorry. The stanchion also provides a means of securing the tailboard and drop-side independently of one another. If there are no rear stanchions, then the opportunity should be taken to fit them, because they will add considerably to the life of the lorry; they may be purchased ready for fixing from a supplier of body fittings such as Messrs. Stedall & Co., 164 High Holborn, London, W.C.1.

End Posts

Assuming that the stanchions are in position, the slatted superstructure is completed by the addition of end posts which form as closely as possible an upright extension of the stanchions (Fig. 1). The end posts may be of angle-iron, and drilled so that the ends of the lengthwise slats may be screwed to them after a wood filling-piece has been inserted and recessed for the end of the slat (Fig. 1A).

If angle-iron is not available, then the end posts may be of hardwood, such as ash or oak, which is recessed to take the full substance of the lengthwise batten.

Fixing the Superstructure

The superstructure is attached by bolting the uprights to the drop-side, with the heads of the bolts and a washer under them on the inside of the body. The end uprights will probably have to cross the adjacent hinge-iron and, in order to ensure a flat bearing, the upright is recessed for the passage of the iron (Fig. 1B).

Detachable Loading-racks

Another method of increasing the height of the lorry sides includes the fitting of detachable loading-racks or frames. By this means, the high sides may be confined to the front part of the body, or all the loading-racks may be removed when only a normal height of body is required. These racks may be used either with a drop- or a fixed-sided lorry, as shown in Fig. 2.

Loading-rack Parts

A lorry up to 7 ft. 6 in. long may have two racks each side, three racks up to 10 ft. 6 in., and four racks for longer vehicles. Each rack consists of

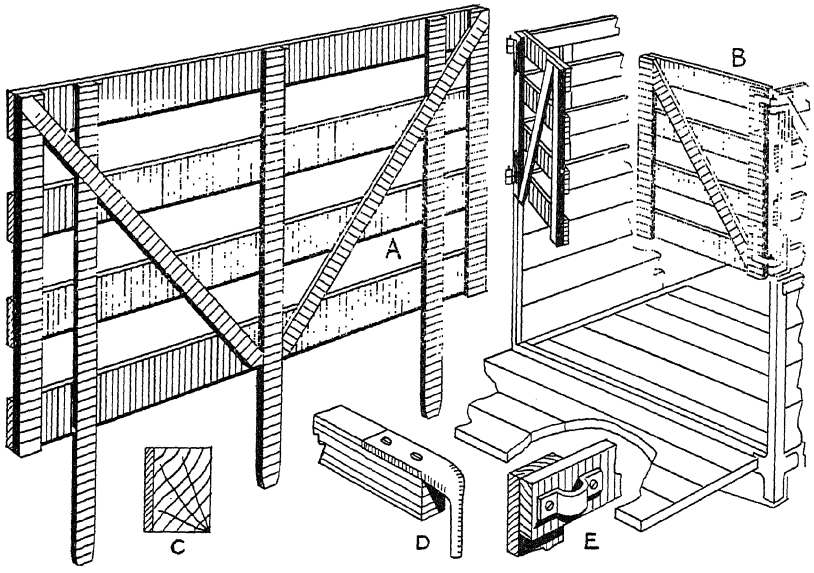


Fig. 3.—A. LOADING-RACK, AS FITTED TO THE LORRY SHOWN IN FIG. 2. B. END GATE ON LIFT-OFF HINGES. C. SECTION OF FLITCH-PLATED SPREADER (*see* FIG. 2B). D. HOOK PLATE OF SPREADER. E. STAPLE ENGAGING WITH HOOK PLATE

similar material to that already mentioned for the drop-sided lorry (Fig. 1), except that the end vertical batten is of similar material to the uprights. The whole is stiffened by means of a pair of diagonal braces of 2-in. by $\frac{3}{4}$-in. deal which are half-lapped across the uprights and end vertical battens.

Supporting the Rack

The uprights are made about 9 in. longer than the body of the rack, so that the feet so formed may pass through upper and lower staples. Instead of an upper staple the top of the lorry side may be reinforced with an outer hardwood rail made from $1\frac{1}{4}$-in. hardwood. This rail is temporarily fixed to the body, and then marked at the rack-upright positions. It is also marked for the recessing of a front plate $5\frac{1}{2}$ in. by $\frac{1}{4}$ in. thick so that, when the wooden rail is cut into sections and replaced on the body, the spaces between these sections form openings for inserting the uprights of the rack, while the front plate, when screwed in place, holds the upright securely in the upper position (Fig. 2A). The staples should be bolted to inside plates of $\frac{1}{8}$-in. iron.

Higher Tailboard

If it is desired to increase the height of the tailboard so that it is as high as the sides, then a loading-frame may be stapled to the tailboard and

opens with it. This extra height of tailboard is apt to be an obstruction when loading if it does not drop clear of the ground. If resting on the ground at an angle, it is easily broken.

Hinged Racks or Gates

The better method of increasing the height of the body at the back is to hang a pair of hinged racks or gates on the ends of the side racks. These end gates are then independent of the opening of the tailboard, although they have a projecting bottom lip plate which bears against the tailboard when it is closed (Fig. 3B). The gates are hung on lift-off hinges so that they are easily removed when necessary. Although the side loading-racks have sufficient rigidity to withstand the normal side thrust of the load, yet a considerable amount of leverage is thus exerted on the sides of the lorry.

Top Spreaders

To compensate for this, top spreaders (Fig. 2B) connect the off- and nearside frames, while at the same time a support is provided for a waterproof sheet. The spreader is curved and, if it has a moderate camber of not more than 3 in. in a length of 6 ft., it may be cut out from a $1\frac{1}{4}$-in. ash plank, and no steam bending is required. The spreader is reinforced on one side with a flitch plate of $\frac{1}{8}$-in. mild steel (Fig. 3C), and has a hook plate (Fig. 3D) at each end which registers with a staple (Fig. 3E) on the inside of the loading-rack.

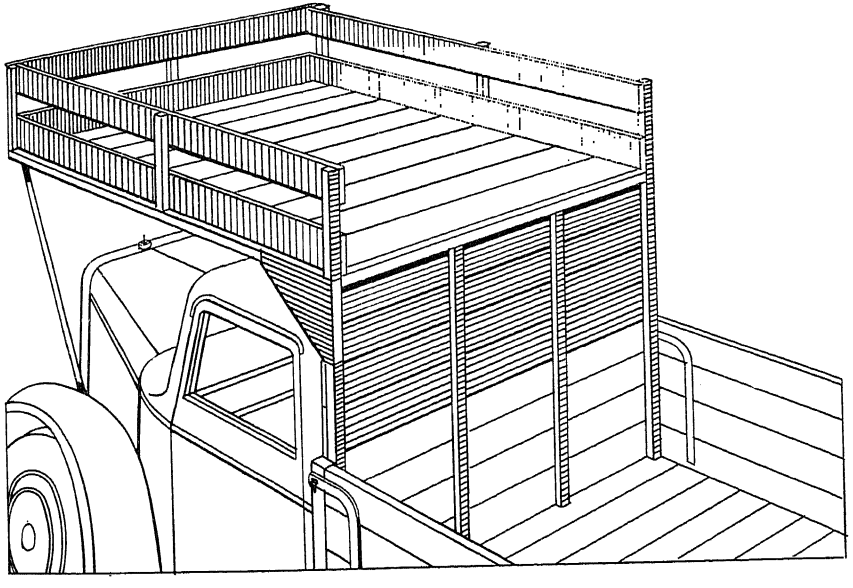


Fig. 4.—LOADING CAPACITY OF LORRY INCREASED BY MEANS OF A PLATFORM ABOVE THE CAB ROOF AND BONNET

Front Racks

Similar loading-racks may be secured in front of the body, or the front boarding may be extended so that the lorry has a high, close-boarded front, similar to the lorry shown in Fig. 4.

Building Platform above the Cab

Another method of increasing the loading capacity of a lorry is to build a platform above the cab roof (Fig. 4). This scheme may be adopted for a vehicle with normal or forward control, but with normal control there is the advantage, if a large area of platform is required, that it may extend over the bonnet.

Corner Pillars

To build this platform, corner pillars of $1\frac{1}{2}$-in. by 2-in. ash or oak are fitted in the front corners of the lorry, extending from the floor to the top of the platform enclosure. The 2-in. dimension of the corner pillar is placed parallel with the width of the lorry and on the inside of the front boarding of the body, which is usually of $\frac{3}{4}$-in. deal. The lorry, as a rule, is already provided with outside front corner plates, which may be utilised to secure the foot of the pillar. The existing bolts are removed and replaced by longer ones.

Intermediate Pillars

Two intermediate pillars are now required, the length of which is determined by the height of the platform floor. These pillars, also the higher corner pillars, are half-lapped to the rear cross-rail of the platform, which supports on top of it four lengthwise bearers. The floorboards are laid crosswise directly on these bearers. The front boarding of the lorry is continued upwards to the rear cross-rail.

Platform Cross-bearers

Cross-bearers 2 in. by $1\frac{1}{2}$ in. are bolted under the lengthwise ones. There is a cross-bearer at the front of the platform, and another midway between it and the rear cross-rail. Stump pillars 8 in. high, or according to the height of platform enclosure required, are lapped to the outer lengthwise bearers. Battens $\frac{5}{8}$ in. thick are screwed on the inside of the stump pillars and form the enclosure. In order to strengthen the joint between the front of the lorry and the back of the platform, a gusset plate of $\frac{1}{8}$-in. sheet steel is screwed on the outside of the outer lengthwise bearer and corner pillar.

Front Stays

The front of the platform is supported on a pair of stays of $\frac{3}{4}$-in. round iron which converge towards the bottom and have flaps so that they may be bolted to the chassis.

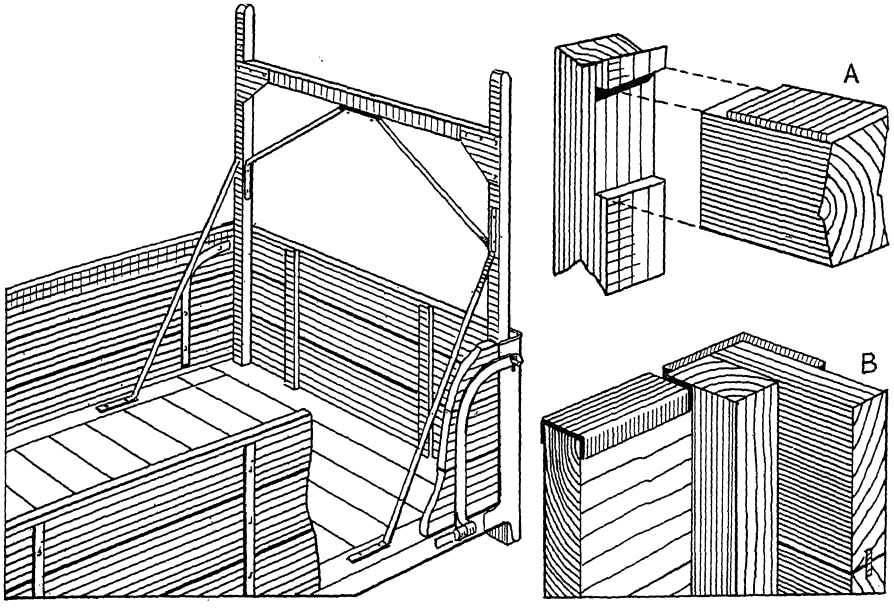


Fig. 5—DROP-SIDED LORRY FITTED WITH A FRONT GANTRY FOR CARRYING TIMBER
A. Joint of cross-bar and pillar. B. Cross-section of front gantry pillar at top of lorry side.

FRONT GANTRY

The utility of a drop-sided lorry is increased if it is fitted with a front gantry (Fig. 5), so that it may carry timber and other lengthy articles. The corner and intermediate pillars with their cross-rail, already described for supporting the rear edge of the loading platform above the cab (Fig. 4), could be utilised as a gantry, especially if the lorry has a high boarded front.

Top Bevel of Cross-rail

With the front of the lorry the same height as the sides, the gantry consists of a pair of 2-in. by $2\frac{1}{4}$-in. wooden pillars, the feet of which are bolted to the front corners of the lorry. The cross-rail (Fig. 5A) is 2 in. by $2\frac{1}{2}$ in., with its top surface bevelled. This bevel is obtained by drawing to scale a triangle the base of which represents the length of the lorry and its height the distance from the floor to the top of the gantry cross-bar. Completing the triangle the hypotenuse represents the slope of the load, also the correct bevel for the top of the cross-rail.

Cross-bar and Backstays

The joint of the cross-rail with the pillar is reinforced with a gusset plate of $\frac{1}{8}$-in. sheet steel, and the top edge of the cross-bar with a length of

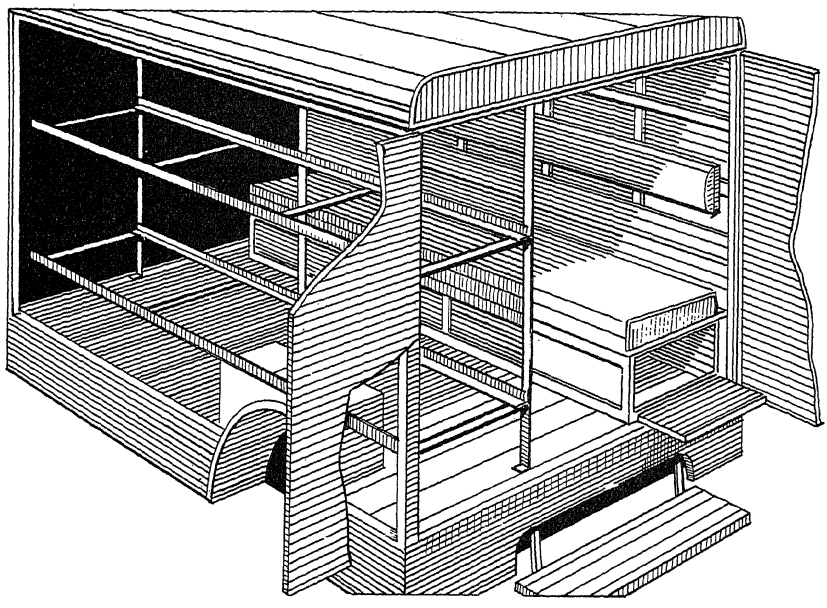


Fig. 6.—VAN CONVERTED INTO AN AMBULANCE WITH ALL-METAL STRETCHER BASE ON THE NEARSIDE FOR TWO STRETCHERS AND A LONG SEAT ON THE OFFSIDE

2-in. by $\frac{1}{4}$-in. flat mild steel. The gantry is strengthened by a pair of diagonal stays of $\frac{3}{4}$-in. round iron which are flapped under the cross-bar and to the inner face of the pillar. There is also a pair of backstays which prevent undue strain on the front of the lorry and distribute the thrust of the load.

Lower Fixing of Backstay

These backstays are also of $\frac{3}{4}$-in. round iron, and are flapped on the back of the pillar and on top of the bottom side. The last named is the outer lengthwise member of the bottom framework of the body. Its top surface may be exposed if the edges of the floorboards are rebated into it. Otherwise the floorboards are laid on top of it. In any case, the bolts which hold the lower end of the backstay must pass through the bottom side and not through the floor only, so as to ensure a secure fixing.

CONVERTING BOX VANS TO AMBULANCES

The adaptation of existing bodywork so that the vehicle may be used as an ambulance for A.R.P. work, either for official use or as part of the civil-defence equipment of a factory, is a means of providing this special form of transport for a moderate outlay. A box van is the most suitable type of vehicle for this kind of conversion. The lower the floor the better

and, in any case, a van which has a floor entirely above the hind wheels, that is, without inside wheel-arch enclosures, should not be used.

Wide Rear Opening

At the back there should be a pair of doors so as to afford a wide opening convenient for loading. Also, it is an advantage if these doors open the full width of the van, so that a loaded stretcher may be slid into the ambulance close to the side of it. When the van has only a single door at the back this should be at least 30 in. wide, but if the vehicle is suitable in other respects it is worth while altering it by increasing the width of the back opening and hanging a new pair of doors.

Length Required for Stretcher

The most important consideration when selecting a van for conversion into an ambulance is its length. A service stretcher is 7 ft. 9 in. long over the handles, so that at least 8 ft. inside accommodation is necessary. Any extra length available will be valuable to provide a cross-gangway, or for adding a crosswise seat for sitting patients.

Width of Stretcher and Seat

Regarding the inside width of the bodywork, this should not be less than 5 ft. 2 in. A good average width is 5 ft. 6 in., so that a central gangway at least 14 in. wide is available. Each stretcher is 1 ft. 10½ in. wide, and the stretcher base, if of metal, will be about 2 ft. overall, and a wooden stretcher base two or three inches wider. More width is required for a vehicle with stretchers on both sides than for one which has stretchers on one side and a seat on the other. This is because the width of the seat need not exceed 1 ft. 6 in., or 6 in. less than the minimum width of a stretcher base.

Ambulance Headroom

A van which has a minimum length of 8 ft. will usually have sufficient headroom for the stretcher-bearers to enter the ambulance. The inside height from the floor to under the crown of the hoopsticks, or roof framework, should not be less than 5 ft. 10 in. for the stretcher-bearers to stand upright, but even with specially built ambulances this dimension is often reduced to 5 ft. 6 in., which is sufficient if the bearers do not enter the vehicle when loading the stretchers into it. This dimension is also sufficient for a stretcher base which accommodates upper and lower stretchers.

No Extra Load Entailed

As the van of the required length has been designed to carry at least 15 cwt., its new use will not entail the carrying of any extra load, because allowing 1¼ cwt. for each adult, 15 cwt. represents the total weight of twelve adults, or eleven adults and 1 cwt. of stretcher base and other equipment.

Two Types of Equipment

As already indicated, there are two leading types of equipment for the converted ambulance. One consists of a base on the nearside for two stretchers and a lengthwise seat on the offside for sitting patients and one or two attendants, as shown in Fig. 6. The other type of ambulance has a double stretcher base on each side with a seat for the attendant facing the rear at the front end of the central gangway.

Construction of Stretcher Base

A stretcher base is made of $1\frac{1}{2}$-in. by $1\frac{1}{2}$-in. angle- and flat-section mild steel. For a base of 8 ft. long, three stanchions of flat-section steel are required for each side, so that the assembly is supported entirely from the floor. The lower pair of stretcher runners should be as close as possible to the floor, and their height is determined by that of the wheelarch enclosure. The upper pair of runners is placed 2 ft. above the lower ones. Assuming that the wheelarch enclosure is 12 in. high, and 6 in. is allowed above the top pair of runners, the stanchions will be 3 ft. 9 in. high. The stanchions may also be extended so that they may be fixed to the roof framework, which is advisable if one pair of runners is attached to the body side instead of to independent stanchions.

Securing Cross-bars and Stanchions

The stanchions are connected by flat-section cross-bars, which are cut 2 ft. 3 in. long, so that $1\frac{1}{2}$ in. each end may be turned at right angles for bolting to the inside of the stanchions. The angle-iron runners are then laid on the cross-bars and bolted or spot-welded. The assembly is completed by bolting it to the floor with an angle-bracket secured on the inside of the foot of each stanchion.

Floor Repairs

Before fixing the stanchions the floorboards should be examined and faulty ones replaced, or loose ones made secure. A thin floorboard may be reinforced with a batten on the underside at the bolt position of the stanchions.

Long-seat Construction

The lengthwise seat, without the cushion, is 1 ft. 4 in. high, 1 ft. 6 in. wide, and as long as the inside length of the van. The seatboard consists of three 6-in. by $\frac{3}{4}$-in. boards, battened on the underside with four 3-in. by $\frac{3}{4}$-in. battens. The seatboard may be supported at the back on an existing rave, or lengthwise rail of the body framework. Otherwise an extra rail is screwed to the pillars at the required height.

Heelboard of Seat

The heelboard, or the board which supports the seat in front, is made of a framework of 3-in. by $\frac{3}{4}$-in. battens panelled on the inside with ply-

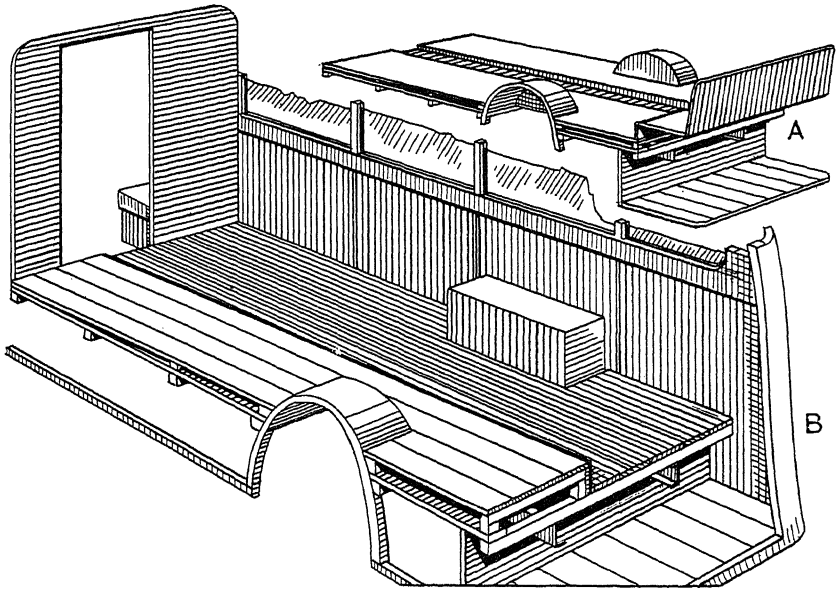


Fig. 7.—CONVERTING COACH INTO VAN

A. Ramped floor of coach with sunk central gangway, also showing position of back seat and floor of rear locker. B. Converting a coach into a van. The offside portion of the ramped floor has been made level with the central gangway, also the wheelarch made up into a rectangular enclosure. The back seat has been removed and a partition added behind the driving-seat.

wood. A similarly panelled framework may support the seat at the back, so that it is a box-like structure without a bottom, except for four cross-bars of 3-in. by $\frac{3}{4}$-in. material which are lapped to the bottom rail of the heelboard and backboard. If the seat is built into the body, then the heelboard is attached to the floor by small corner plates. With the box form of construction three screws in each bottom cross-bar will be sufficient to keep the seat in position.

Locker Space

The seat, except for the obstruction of the wheelarch, forms a comparatively large enclosure which may be used as a locker for first-aid supplies or an extra folded stretcher. Access is afforded by hinging portions of the heelboard, while the stretcher is easily accessible if an end door is fitted, as shown in Fig. 6.

Back Rest

The equipment for sitting patients is completed by adding a back rest. This consists of a 1-in. board 8 in. wide, which is screwed to the pillars at a height of 2 ft. above the seatboard, measuring to the top of the back rest.

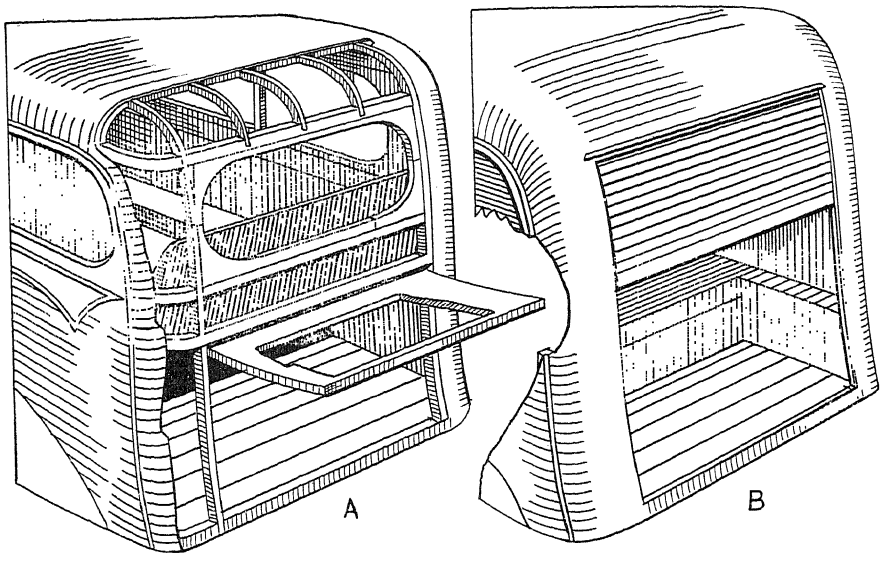


Fig. 8.—CONVERTING COACH INTO VAN

A. Back of coach with panels removed before cutting rear opening for conversion into a van. B. Rear opening completed and fitted with a roller shutter.

This is stuffed with horsehair or other suitable filling and covered with leather cloth.

Back Steps

If the ambulance is to carry sitting patients easy access to the floor level should be provided. A single step with a tread about 8 in. wide should be fitted for a floor not more than 24 in. high, and a double step for a floor height from 24 in. to 34 in.

CONVERTING A COACH INTO A DELIVERY VAN

A new coach may have been completed and it cannot be placed in service owing to fuel rationing, or it has been built for stock or exhibition and is difficult to sell owing to restrictions of services. In other instances, a coach body has been partly constructed and work on it has been abandoned owing to the conditions prevailing. Also, second-hand coaches may be awaiting new owners. Whether new or second-hand, there is the opportunity of using these vehicles by converting them into delivery vans. The coach will make a large-capacity van, and will probably weigh more than 50 cwt. unladen, so that it will be subject to a speed limit of 20 m.p.h.

Removal of Interior Equipment

The equipment to be removed from a completed coach includes the passenger seats, also the back seat, which is built into the body, and the inside parcel racks and any lamps which project from the sides of the body. The windows are removed and plywood panels of the same thickness are substituted for the glass.

Alterations to the Coach

The coach usually has a ramped floor on each side under the seats which slopes upwards to the rear (Fig. 7A), with a sunk gangway between them. The sunk gangway must be made level with the floor under the seats, and if the ramp is sufficiently sloped to cause the load to shift towards the front, then the floor is relaid and the cross-bearers which support it are altered so as to provide a horizontal bearing. The usual front sliding door and the hinged offside emergency exit opposite to it are not suitable for goods loading, except for small packages. Therefore, the back of the coach is cut away so that a pair of doors or a roller shutter may be hung here (Fig. 8B). The rear luggage locker, which is usually built under the hind seat, is incorporated into the main portion of the body, and provides an easy means of access to it (Fig. 8B).

Relaying the Floor

If the floor has to be relaid, then the raised portions which were under the seats are removed, also the framework which supports them. By this means the main cross-bearers at the sunk gangway level are exposed. The floor at the sides of the body is then relaid so that the floor is at the same level throughout.

Rectangular Wheelarch Enclosure

In order to separate the loading portion of the body from the driving compartment, a partition is built between them which may have an opening in it fitted with a sliding door. The position to select for the partition is the nearest body pillar behind the driving seat. The uprights of the framework which support the boarding of the partition are screwed to the body pillars. All pillars of the partition, including the intermediate ones, are screwed at the top to the roof framework and at the foot to the cross-bearer. This part of the work is done before relaying the floor.

Removing the Back Panelling

The back of the coach has now to be provided with an opening suitable for a delivery van. The mouldings are removed so that the panels may be detached and the framework exposed, as shown in Fig. 8A. The door of the luggage locker is removed, also the back-light framework. The cross-rails at the waist are cut through, but not the rail immediately above the back-light, which is to be the top rail of the new opening. A

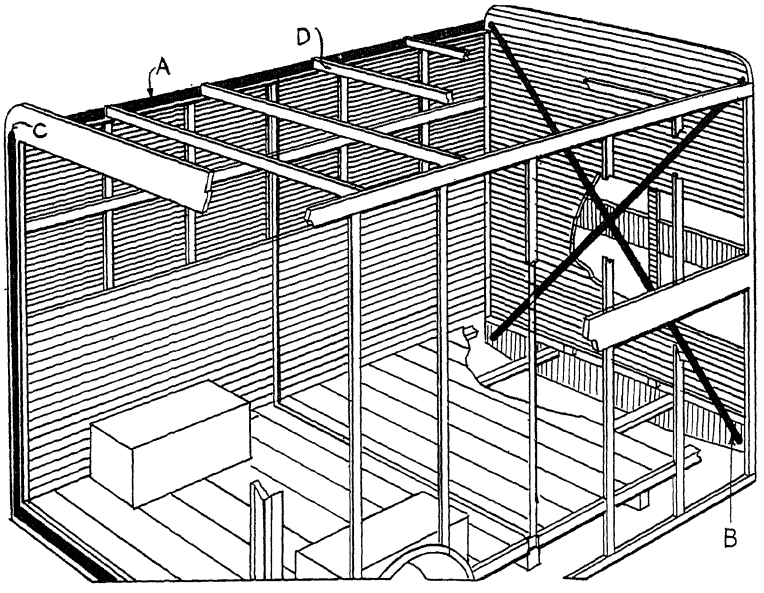


Fig. 9.—REINFORCED FRAMEWORK OF DELIVERY VAN

Angle-irons A, front braces B, and hind body plate C, placed so that the van may be used for carrying meat with the carcases hung by hooks from the cross-rails D.

sufficient area of the domed top back panel is replaced and replenished where necessary.

Roller Shutter Preferred

The rear opening so formed may be fitted with a pair of doors, a tail-board with a pair of smaller doors above it, or a roller shutter. As the back of the body is curved, the roller shutter will be the most economical plan, because it will adapt itself readily to the curved shape. The making of a pair of curved doors entails considerable expense and, owing to the inclination of the hinge centres, the doors will require stays to keep them open when loading the vehicle.

CONVERSION OF VAN TO CARRY MEAT

The majority of box-van bodies are designed for carrying a load piled on the floor, or some of the articles are carried on shelves. But it is only in special cases that the greater part of the load is suspended from the inside of the roof. The framework of the roof of many vans is only strong enough to hold the top of the sides of the body rigidly together and to support, when necessary, an extra load carried on the roof of about 1 cwt. The distribution of meat to centres where the population has been

temporarily increased necessitates the use of more meat vans such as are used for market work. With this type of van the carcases are suspended from the roof, also it is designed so that it may be easily kept in a clean condition.

Strengthening the Sides at the Top

An ordinary box van of from 2 to 4 tons carrying capacity may be converted for carrying an inside roof load by reinforcing the framework. The first requirement is a length of 2-in. angle-iron (Fig. 9A), which runs the full length of the van and is bolted to the pillars or standards immediately below the cant rail, or top side member of the body framework. If the cant rail is of sufficient depth, then the angle-iron may be bolted to it immediately below the roof ribs or hoopsticks, or a new hardwood rail is added to provide the required depth of bearing for the angle-iron.

Front Braces

The front of the body is also strengthened to resist the thrust of the load. This is done by adding a pair of cross-braces (Fig. 9B) of 1-in. by $\frac{3}{4}$-in. flat steel which extend from the top cross-rail to the front bearer under the floor. These braces may be added without removing the front boarding, although it will be necessary to cut a slot in the floor in each front corner in order that the braces may pass through to the bearer below.

Hind Body Plate

The back of the van is probably already stiffened with a hind body plate (Fig. 9C) which extends across the hind bearer below the doors or tailboard. This body plate has flaps extending up each hind-corner pillar.

Bolt Ends for Side Angle-irons

It is an advantage if the angle-irons each side of the roof can be connected to the braces in front and to the flaps of the body plate at the rear. For this purpose a bolt end is welded at each end to the angle-irons. This bolt end then passes through an eye in the end of the front brace and the flap of the body plate, and is secured with a nut on the outside. The flaps of the backplate will require extension, so that they are removed and the required length of flap welded on.

Hygienic Considerations

A meat van should be lined with sheet zinc. This lining includes the sides and front of the van below the waist, also the back doors and floor. As sheet metal may be difficult to obtain, these parts should be reboarded or panelled where necessary so that there are no crevices where dirt may accumulate and be difficult to dislodge. The inside of the body is then repainted.

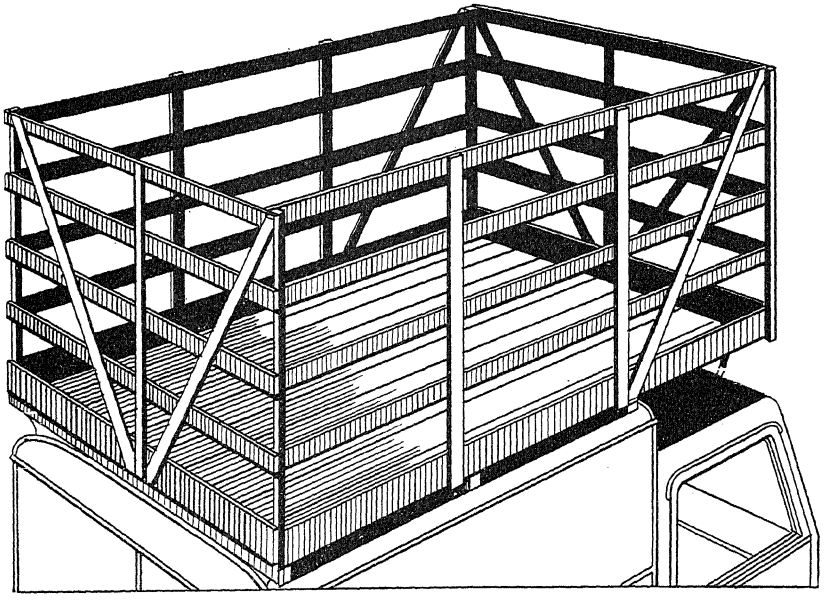


Fig. 10.—LIGHTLY BUILT CRATE WHICH CARRIES A BAG FOR A VEHICLE RUNNING ON TOWN'S GAS

Floor Mats

The floor of a meat van is covered with wooden mats. These consist of 2-in. by $\frac{3}{4}$-in. deal battens, spaced about 1 in. apart and battened on the underside with similar material. A crosswise batten screwed on the floor at the back will keep all the mats in position. The floor is covered with a set of four mats, and if there are wheelarch enclosures, then one pair of mats is designed to fit around them. A mat which covers the floor both in front and behind the wheelarch will keep the mat in front of it from moving. These mats are scrubbed periodically, and, incidentally, they save wear on the floor.

Cross-rails for Meat Hooks

The angle-irons at the top of the body sides not only strengthen the van, but also provide a foundation for a set of cross-rails (Fig. 9D) fitted with hooks, from which the carcases are suspended. The cross-rail is of 2-in. by 1-in. hardwood, and it is flitch-plated on one side with a steel plate $\frac{1}{4}$ in. thick. The ends of these rails have iron pins which drop into holes bored in the side angle-irons, or the cross-rails drop between small brackets made of short lengths of angle which are spot-welded to the side angle-irons. The latter method is to be preferred, because neither the cross-rails nor their supporting angles are weakened by fitting pins or by drilling holes.

MAKING A GAS-BAG CONTAINER

Rationed fuel has brought again into prominence the use of alternative fuels, and for this reason vans and lorries have already been fitted with an equipment so that they may be operated on town's gas. It is estimated that 250 cu. ft. of gas is equivalent to 1 gall. of patrol. Gas bags are made in various sizes, such as to hold 240, 360, 480, and 600 cu. ft. respectively. Each bag is 6 ft. wide and 4 ft. high, and varies in length from 10 to 25 ft. In order to decrease the overall height of the vehicle, such as a box van, part of the gas supply may be carried in a net under the roof inside the body and the remainder in a crate on the roof. Any special size of gas bag can be made to order.

Width and Length of Crate

A lightly built crate for carrying a gas bag is shown in Fig. 10. In order to provide maximum capacity the crate should be as wide as the overall width of the vehicle, and, as the sides of the roof are curved, cross-bearers are placed across the roof to support the side overhang of the crate. The cross-bearers are placed immediately above alternate roof ribs or hoopsticks, so that the cross-bearers may be screwed to them. The crate is also the full length of the vehicle, and the bottom of it may be shaped to conform to a cab roof which curves downwards in front. If the cab roof is at a different level from that of the loading portion, as in Fig. 10, then the projecting portion of the crate is supported on a pair of iron stays.

Height of Crate

The crate may be high enough to enclose entirely the inflated gas bag, or about half of it is allowed to project at the top. In any case, a net is stretched over the top in order to control the movement of the bag whilst the vehicle is travelling.

Construction of Crate

The crate is made of $1\frac{1}{2}$-in. by $\frac{1}{2}$-in. deal battens with braced ends, as shown in Fig. 10, also side braces to add to the rigidity if there is a projecting front portion. One method of constructing the crate is to fix the side frames inside the end frames, and to secure them with corner plates. The floor of the crate may be of spaced strips of plywood, and the sides are left open, or panelled on the inside with plywood.

ANDRE HYDRO-TELECONTROL SHOCK-ABSORBER SYSTEM

By GEORGE T. CLARKE

IN the Andre telecontrol system, although the control itself is hydraulic, the absorber is not. The system is a non-compressible-fluid method of controlling the pressure exerted at the will of the driver on the friction discs of the absorber.

Frictional and Hydraulic Absorbers

Shock absorbers can, broadly speaking, be divided into two characteristically different classes, frictional and hydraulic. With the former the spring-damping resistance is effected by frictional means, in the latter a fluid provides the necessary resistance. Both have the same objective, that is, to control undesirable spring vibration, but differ considerably in action. Hydraulic absorbers depend in their action upon the transfer of fluid, usually under high pressure, from one chamber to another through a small orifice. The system is subject to temperature conditions. Friction absorbers are somewhat simple in action and unaffected by temperature conditions. The damping action with the hydraulic absorber is controlled at the absorber by regulation of the orifice. The friction absorber is controlled by a spring acting on the friction discs.

Components of Telecontrol System

The Andre telecontrol system consists of friction-disc absorbers, dashboard regulators, pressure gauges, fluid reservoirs, and the necessary pipe connections. The copper pipes are $\frac{3}{16}$ in. outside diameter, and easily bent to shape and fitted to the average car if not fitted with the system in the first instance.

Adjustable Shock Absorbers

Shock absorbers of the ordinary fixed-adjustment type, however efficient in actually controlling undesirable spring action, can only be set one at a time, whatever the merits within the absorber itself. To enable the suspension system to give a maximum degree of riding comfort at all conditions and speeds over smooth and rough roads, it is advisable to have a variable damping value and controllable whilst driving. A car carrying only the driver needs a different adjustment of the absorber to the same car carrying a full complement of passengers.

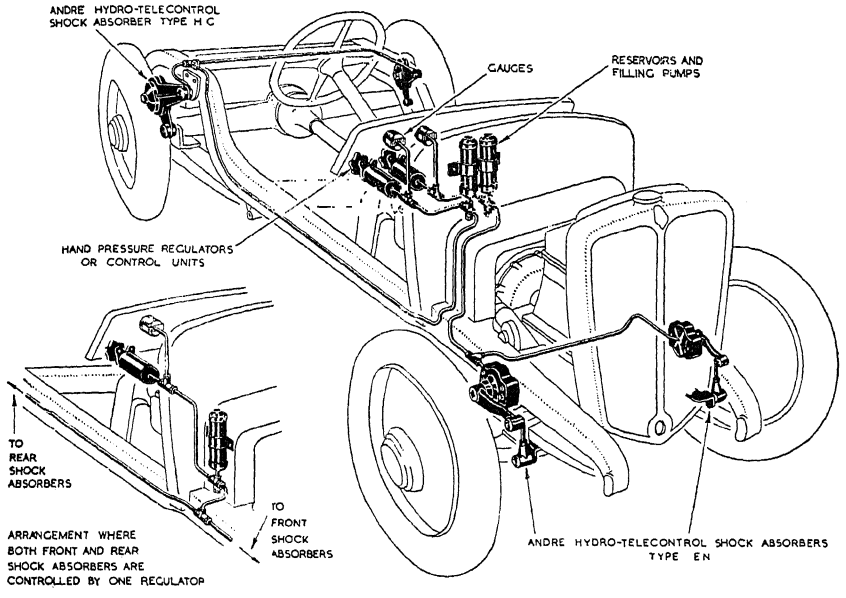


Fig. 1.—GENERAL ARRANGEMENT OF ANDRE TELECONTROL SHOCK-ABSORBER SYSTEM

Assume luggage equal in weight to two rear-seat passengers, but, instead of the passengers the luggage is placed on the platform, thus overhanging the rear axle. The result would not only be felt by the rear absorbers, but the front absorbers would be relieved of certain work by the fact that the front axle has then a tendency to be lifted from the ground. The front and rear absorbers are thus, if good springing is desired, working under different conditions, and therefore should have different adjustment. Passengers plus luggage require another change of both sets of absorbers, and this is what the telecontrol system attempts to attain.

Telecontrol can give either a small damping effect for town use, or slow travel, or, when desired, a greater damping resistance for fast driving, perhaps over indifferent roads.

Advantages of the System

The degree of adjustment with the Andre telecontrol system is instantly regulated from the dash to suit any combination of road, load, or speed conditions. A dash indicator shows the hydraulic pressure controlling the system. The telecontrol system can be disconnected should anything go wrong, and the friction absorber operated as a self-contained unit.

Telecontrol Absorber Unit

The absorber unit comprises a frictional-type absorber and the hydraulic-pressure unit. The two assemblies are self-contained, but are interconnected by means of a central bolt to form the complete absorber, or alternatively, in cases of necessity, the absorber can be operated as on the ordinary frictional system by the adjustment of a regulating nut as used on the original Hartford absorber. The hydraulic unit consists of a rubber expander with internal channels for the fluid. The expander is enclosed in a metal container and held in position by a central bolt connecting with the end plates on each side of the frictional absorber. The metal case forms the protection from climatic conditions.

The Regulator

The regulator consists of a cylindrical casing in which moves the flexible container holding the operating fluid. This container is compressed by means of a screwed plunger attached to the hand-controlled wheel, a pressure equal to that applied in the container being transferred via the connecting pipes to the absorbers. The regulator is almost frictionless and leakproof.

Pressure Gauge

The degree of adjustment is registered on the dash by means of one pressure gauge if all four of the absorbers are under one control, but two gauges if the rear absorbers have a separate control from the front absorbers.

Reservoir and Filling Pump

The purpose of a combined reservoir and filling pump is to facilitate the initial process of charging the system, and to provide a reserve of fluid for the replacement of any loss caused through accidental damage. The whole unit consists of the reservoir containing a hand-operated plunger pump fitted with a non-return valve. The screwed head of the plunger forms the filling cap, which, upon being screwed down, seals the non-return valve orifice.

Pipe Connections

The $\frac{3}{16}$ in. copper pipe forming the line from the controls to the absorbers has no soldered joints, the method being that of double conical nipples such as used with the Autovac system and general American pipe practice.

System of Operation

The damping resistance of the absorber is applied from the control unit by the movement of a column of liquid via the pipe line to the expanders. The liquid, being incompressible, constitutes an hydraulic

force, a pressure equal to that imposed in the regulator being exerted in the expanders. The action is instantaneous. The expander in each absorber, being of equal area and being operated by equal pressure, exerts equal pressure on the friction discs.

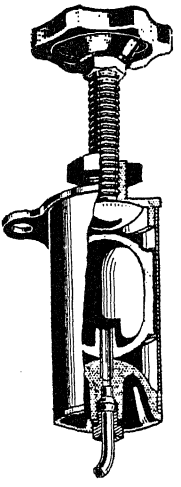


Fig. 2.—REGULATOR SHOWING HAND-WHEEL FULLY OUT

MAINTENANCE INSTRUCTIONS

Under ordinary circumstances the system is trouble-free, but there may be some unavoidable causes or accidental derangement that necessitates the aid of the mechanic to effect rectification or renewal.

Pressure Variation

Temporary variation in pressure indicated on the gauge of a few pounds up or down is not of consequence, as this may be due to variation in temperature of the liquid owing to climatic conditions, etc. Also, in this connection, it may be noticed that the vehicle, after a long run, tends to increase the pressure somewhat. It is due to frictional heat generated, and is unimportant. Should there be constant loss of pressure, investigation should be made.

Refilling Regulator

The absorbers may become inefficient through loss of liquid, due to accidental damage, or leakage when connecting up. If the leak is not serious and is indicated only by a gradual drop in pressure over a period, or if the desired pressure cannot be obtained even when the regulator is screwed right down, the system can be temporarily "topped up" by means of the reservoir pump until such time as it may be convenient to trace the cause of the trouble. If the loss of pressure is rapid, then the leak, if any, must be traced and cured immediately. After such a leak it will be necessary to refill the regulator, Fig. 2.

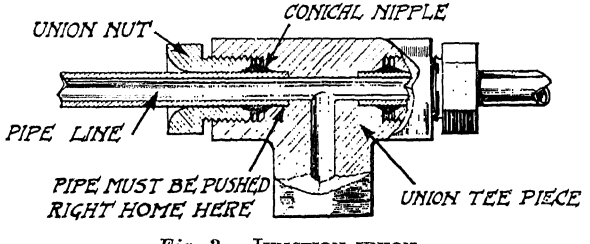


Fig. 3.—JUNCTION UNION

Showing the double conical nipples and the need for carefully pushing the pipe lines right home before doing up the union nuts.

With the hand-wheel right "in" to the end of its travel, begin to pump fluid from the reservoir filling pump until the

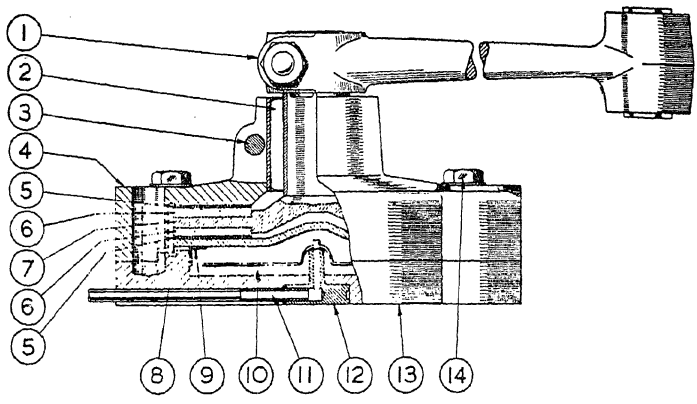


Fig. 4.—MODEL E.N. SHOCK ABSORBER

1, Absorber Arms. 2, Silentbloc Bush on Spindle. 3, Bush Coupling Bolt. 4, Top Half Case. 5, Interleaving Discs. 6. Friction Discs. 7, Rotor. 6, Pressure Plate. 9, Retaining Ring. 10, Hydraulic Expander. 11, Control Pipe end. 12, Control Pipe Connector. 13, Lower Half Case. 14, Four Bolts securing Half Cases.

gauge reads about 50 lb. per square inch, then unscrew the hand-wheel until the pressure drops to 10 lb. per square inch. Pump in enough fluid to raise the gauge pressure again to 50 lb., and reduce once more to 10 lb. by unscrewing the hand-wheel. Repeat this sequence of operations until the hand-wheel is unscrewed to the limit of its travel with a gauge reading of 20 lb. Finally, screw the pump plunger firmly down to seal the system. This method ensures that no air is drawn into the system. If, for any reason that cannot be ascertained or remedied, the hand-wheel when screwed to the limit of its inward travel does not develop a near maximum on the gauge, and this pressure is desired, a little more fluid may be pumped into the system until the gauge shows approximately 30 lb. pressure. The higher pressure should then be easily obtained. During these operations the reservoir must at least be half-full, otherwise air may be pumped into the system.

Union Leakage

This is indicated by gradual loss of pressure, necessitating very frequent adjustment of the control unit. Unless they have been disconnected several times, the nipples seldom give trouble; after this the conical nipples may have become dislocated and new cones should be fitted (*see* Fig. 3). A nipple in use becomes embedded in the pipe and cannot be removed, therefore the pipe end close to the nipple must be cut off squarely. This shortens the pipe, but a short length can generally be gained by straightening out somewhat the nearest bend or curved part

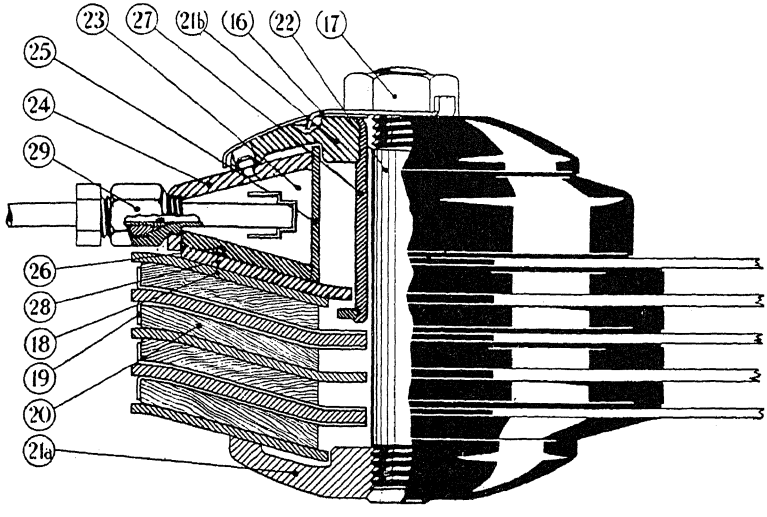


Fig. 5.—MODEL H.C. SHOCK ABSORBER

16, Locking Washer. 17, Lock Nut. 18, Absorber Arms. 19, Friction Plates. 20, Friction Elements between Absorber Arms. 21A, Clamping Plates, 21B, Clamping Plates. 22, Central Bolt. 23, Rubber Expander. 24, Metal Cover. 25, Sleeve. 26, Disc. 27, Flanged Sleeve. 28, Disc. 29, Control Pipe Union Nut.

of the pipe line. When fitting nipples, be sure to clean the burrs off the end of the pipe, but do not file the surface on which the cone has to fit. See that the pipe is well home in the housing before tightening; also do not tighten too forcibly.

After a leak has been rectified, more fluid may be needed. In this case always connect the pump up loosely at first, then force a little fluid past the loose connection before tightening up. This means that any air trapped in the pump connection will be expelled before entering the pipes. Any joint that has been unscrewed, or a joint re-made, should be " bled " whilst it is being tightened.

Defective Expander—Model E.N.

In this case there is a fair drop in pressure, and the liquid can be seen issuing from the absorber when the control unit is being operated. Should it not be possible to return the unit to the makers, who are best fitted to make the repair, it will be necessary to replace the defective unit.

Referring to Fig. 4, after disconnecting the absorber from the chassis by removing the two fixing bolts, take out the four bolts (14) and separate the two halves of the absorber casing (4 and 13). Disconnect pipe connection (12) by means of a small lever or screwdriver in the groove provided. Retaining ring (9) and the expander (10) are lifted out to-

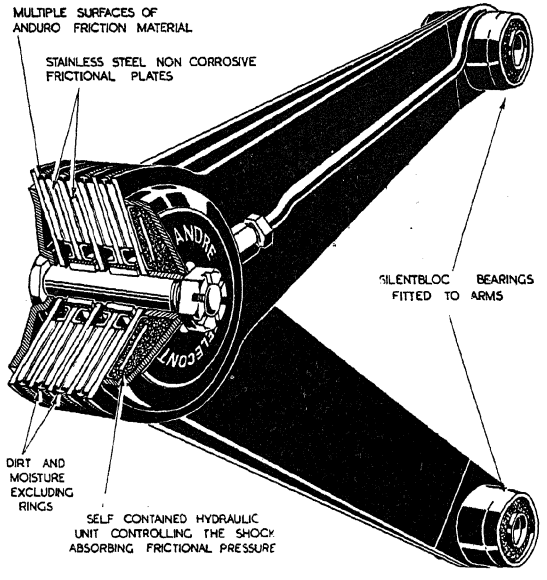


Fig. 6.—SECTIONAL VIEW OF TYPE H.C. ABSORBER

gether, and the new expander is fitted into the base. The absorber should next be reassembled and the pipe connector (12) reinserted. It is advisable to moisten the portion of the pipe connector (12) which enters the rubber expander (10) with water before inserting. Replace and refill as instructed.

Defective Expander —Model H.C.

The special construction of this type of telecontrol absorber enables the hydraulic unit containing the expander to be readily disconnected without dismantling any part of the absorber frictional elements, or removing the absorber from the car (*see* Fig. 5).

Pull out the connecting pipe by unscrewing the union nut (29), then bend down the upturned edges of the lock washer (16). Unscrew locknut (17), and the complete operating unit can then be lifted off the centre bolt and the replacement effected. In this connection it is pointed out that the Model H.C. absorber can be operated entirely independently of the hydraulic control should there be a failure of the latter. The absorber operates as a normal friction damper by simply tightening up the external locknut (17). This operation compresses the rubber expander, and closing the inner cavities it excludes all liquid. The expander will then merely form a rubber pad, and any desired pressure can be exerted on the frictional elements by suitable adjustment of the locknut (17).

Frictional Section of the Model H.C. Absorber

The absorber comprises the arms (18), and these are faced with non-corrosive plates (19). The damping resistance is provided by frictional elements (20) which are interposed between the faces of the arms. The clamping plates (21*a* and 21*b*), one on each side of the absorber, are held in position by the central bolt (22). The nut (17) regulates the initial

pressure on the expander in the hydraulic operating unit; this adjustment is determined on assembly, and the adjusting nut (17) locked in position by the tag washer (16).

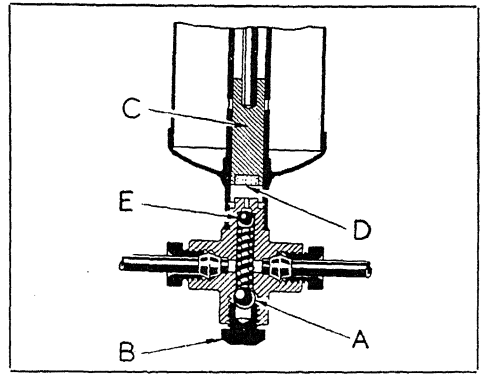


Fig. 7.—SECTIONAL VIEW OF LOWER PORTION OF RESERVOIR AND PUMP

A, Lower Ball. *B*, Screwed Plug. *C*, Plunger. *D*, Rubber Washer. *E*, Top Ball.

Operating Unit of Model H.C. Absorber

The self-contained assembly comprises the rubber expander (23), in which there are ducts to hold the operating liquid. The expander is encased by the metal cover (24), the sleeve (25), and the disc (26). Into the clamping plate (21*b*) is fixed the sleeve (27) with a flanged lower end forming a stop for the disc (28), which controls the movement of the expander. A union nut (29) is screwed into the metal cover for connecting to the dash control.

Frictional Section of Model E.N. Absorber

The assembly (Fig. 4) consists of an aluminium-alloy case in halves (4 and 13), the rotor (7), and the expander (10). The pressure is exerted by the expander (10), and the damping resistance obtained by the friction discs (6), which are interposed between the non-corrosive faces of the interleaving discs (5) and the faces of the rotor (7). The pressure is evenly distributed over the friction area by the pressure-plate (8). The rotor is pivoted in a silentbloc bush (2) to eliminate noise and wear. No lubrication to the bush is necessary.

Special Points when fitting the Model E.N. Absorber

Care should be taken that the clamping bolt (3) is left slack until the link and arms have been connected to the axle of the car. This enables the silentbloc bush to take its correct, and neutral, position in the housing. When everything is lined up and connected, the bolts (1 and 3) must be fully tightened.

Pipe Line and Regulator

A broken pipe or defective regulator means an immediate loss of pressure. The leak will be seen at the respective failures.

Defective Pressure Gauge

When the telecontrol is separate for front and rear axles, the gauges can be compared by interchanging, but if only one control is fitted for all

four absorbers the gauge should be sent to the makers for calibration, and the gauge pipe temporarily plugged.

Loss of Pressure in Reservoir and Filling Pump

Leaking ball valve.—Should the valve not be seating properly it will not be possible, except momentarily, to obtain any pressure on the gauge. The loss of pressure may be caused by foreign matter underneath the ball valve at the bottom of the reservoir, which allows the liquid to flow back into the reservoir instead of going into the pipe line. The latest model, shown in Fig. 7, incorporates the three-way union to make the necessary connections. In order to remove the ball valve, it is necessary only to remove plug (*B*), when the spring balls (*E*) and (*A*) will drop out. Examine, clean, and replace the ball (*E*), then the spring and ball (*A*). Do not forget to see that the plug (*B*) is tight but not overstrained. The rubber washer (*D*), which is inserted in the base of the plunger (*C*), forms a seal when the plunger is screwed right down.

The Hydraulic Fluid

The fluid as supplied by the makers consists of a 30-per-cent. solution of pure glycerine and distilled water, and should be easily obtained from a reliable chemist. The fluid used for other types of absorbers or brakes must not on any account be used. It has been manufactured for an entirely different purpose and therefore will ruin the system. If the correct solution cannot be obtained, the system can be filled with water (somewhat dangerous in deeper winter, owing to freezing), but as a very temporary expedient only.

Fitting Instructions

In view of the fact that the system is not fitted to all cars as standard, fitting instructions are given in so far as it enables the operator to overcome difficulties that may not be foreseen when the task is undertaken. The advice is based upon experience, but is not intended to show the fitter his business.

The usual arrangement where two regulators are employed is shown in Fig. 1. This provides independent control for both front and rear absorbers; therefore pressure can be varied for each pair as desired.

Two or One Controls

One regulator, indicator gauge, and reservoir-filling pump can serve to control all four absorbers, as shown in the inset in Fig. 1. The method is particularly applicable to smaller cars, and in this case all four absorbers are operated at the same pressure. The regulators should be fitted within easy reach of the driver, and the steering column or the instrument board is found to be the most convenient position. The gauges should be fitted well within view of the driver, so that he can readily see the desired press-

ure. The reservoir-filling pump, or pumps, must be placed in a vertical position, and the bulkhead under the bonnet is suggested as a suitable place. The pipe line should present no difficulties.

Fitting the Absorbers to the Chassis Frame, etc.

Two methods of fitting the absorbers are provided: (1) by a direct fitting to the chassis frame (Model E.N.), and (2) by means of brackets and studs in a similar manner to the ordinary type Andre-Hartford absorbers (Model H.C.). In the latter connection, if brackets are already fitted, the telecontrol system usually replaces without difficulty. Blue prints are supplied by the manufacturers to simplify the process. Clips of the correct type are provided for the pipe line. When there is likely to be movement where the line leaves the body and is fastened to the chassis, it is wise to leave a helix in the line to take up any play in body movement. After the line is in place leave the pipe ends adjacent to the absorbers, regulators, and gauges, loosely connected. They should not be tightened up until after filling, but connect up all other unions securely, including those to the reservoirs. When tightening the union it is important that the pipes are pushed right home into the shoulder of the union. Unless this is done there is liability to leakage. When tightening the unions to the T-piece, Fig. 3, under the reservoir and filling pump, always hold the hexagon nut on the outlet pipe to prevent strain. The conical nipples, supplied for making the pipe connections, take the place of the steel balls fitted to the absorbers for sealing purposes only. Each absorber and regulator is filled when it leaves the factory.

THE MORRIS TEN CHASSIS

SERIES M

Removal of Rear-axle Differential Assembly

RAISE the rear end of the car by suitable lifting tackle and support the rear axle on suitable axle stands, with the wheels clear of the ground.

Uncouple the propeller shaft at the rear universal-joint flange by removing the four bolts fastening the two halves of the flange together.

Remove the two wheels and unscrew the three countersunk-headed screws which retain the brake drum in position on the axle flange, and withdraw the brake drums.

The axle flanges should now be parted from the hub flanges by inserting two of the countersunk brake-drum screws into the two tapped holes in the axle flange, and using them as extractors.

Withdraw the axle shafts until they are clear of the differential assembly in the centre of the axle.

Remove the drain plug under the banjo of the axle casing, and allow the oil to drain away into a suitable receptable.

Release the jackall pipe, when fitted, by removing the two nuts with spring washers which attach it to the nearside of the differential housing, and carefully spring the pipes so that they are clear of the differential-housing flange.

Unscrew the remainder of the nuts retaining the differential-housing flange to the banjo, thus permitting the removal of the differential assembly complete.

Adjustment

The differential assembly follows normal Morris practice, except that tapered-roller bearings are employed and that the adjustment for the crown-wheel position is effected by means of ringnuts in place of the castle nuts previously employed. Otherwise the method of adjustment remains the same in principle, and the same care must be taken not to overtighten the crown-wheel bearings.

Removal of the Front Axle

Raise the front end of the car on suitable lifting tackle so that the front wheels are clear of the ground, and place suitable supports under the frame just behind the rear-end shackle brackets.

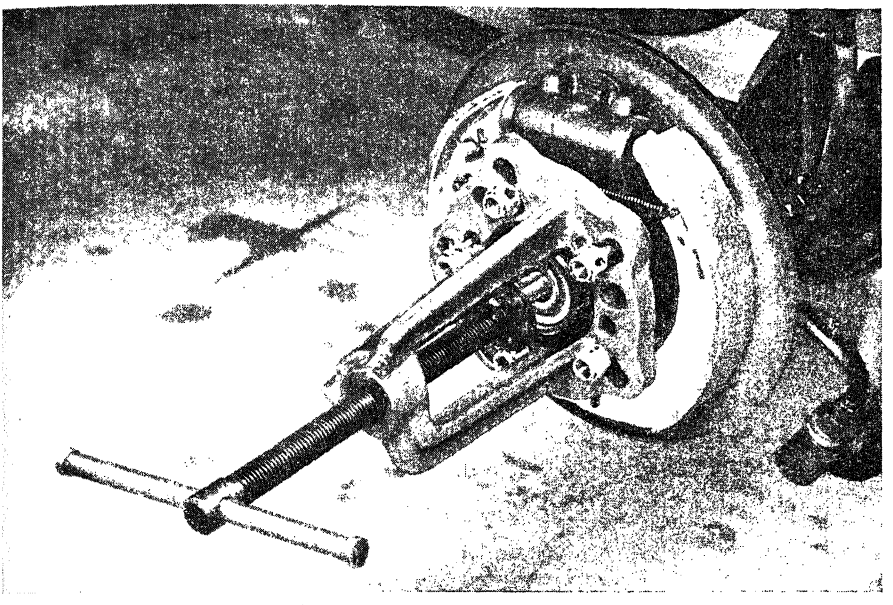


Fig. 1.—REMOVING THE HUB

The front hub is extracted from the axle, after removing the retaining nut, by the use of a standard hub extractor, as shown.

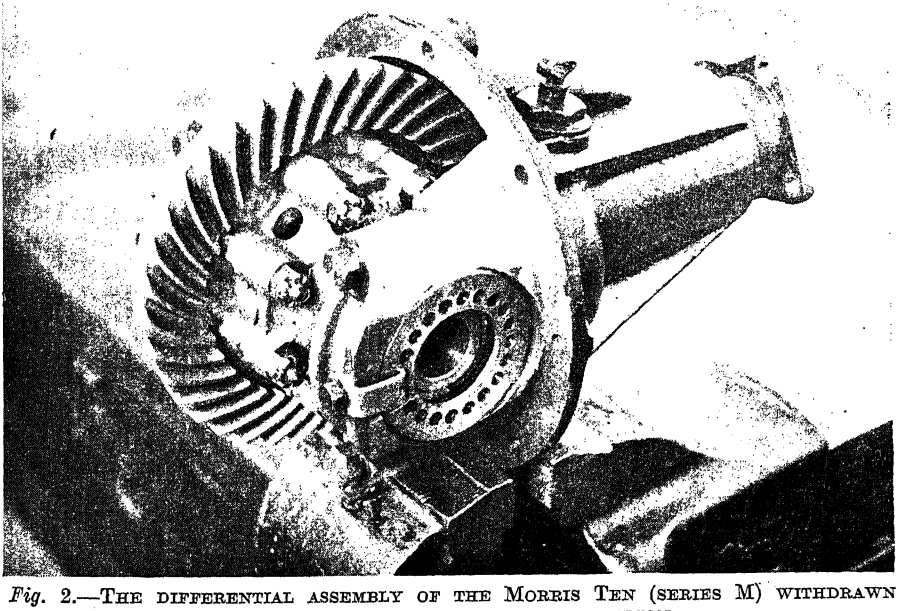


Fig. 2.—THE DIFFERENTIAL ASSEMBLY OF THE MORRIS TEN (SERIES M) WITHDRAWN FROM THE CAR FOR EXAMINATION AND ATTENTION

Remove the wheels and support the weight of the axle by placing a jack under its centre so as to take the load off the check straps.

Release the flexible pipes of the Lockheed brakes from the brake backplates, and, when jackall jacks are fitted, the flexible pipe leading to the front hydraulic jacks.

Remove the bolts attaching the check straps to the lug on the top spring plate, and release the shock-absorber connecting links by removing the bolts locating them to the front-axle brackets.

Unscrew the nuts and remove the shakeproof washers from the screws locating the torsion bars to the pressed-steel brackets on the front axle. Employing a suitable drift, carefully tap out the retaining screw half-way only.

By varying the extension of the jack under the axle a point will be found where the tension of the torsion bar is at a minimum. Keeping the axle in this position, the load on the screw should be further released by the use of a cranking iron on the axle beams. While an assistant applies downward pressure on the cranking irons to bring the torsion-bar bracket forward into the position where no load is placed on the retaining screw, the operator should manipulate the screw so that the degree of tension can be felt and the screw removed, as soon as it is free, without damage.

Release the lubricating pipes from the shackles at the rear end of the front springs by unscrewing their unions, and undo the setscrews which anchor the pipes to the shackle bolts.

The axle is now lowered by means of the jack until the load is removed from the rear shackle pins. Remove the nuts from the shackle pins and withdraw the side plates, remembering that the shackle pins are of the screwed type and cannot be knocked out. Remove, also, the felt washers beneath each shackle plate.

The forward anchorage of the springs is now released by slackening the anchorage pins of the rubber-backed bearings, noting that *fibre* washers are fitted to each side of the spring eye in this case.

With the help of an assistant the jack can be removed and the axle lowered on to the ground, permitting complete removal of the anchorage pins and final release of the axle assembly.

When reassembling it must be remembered that it is essential to centralise the pins of the screwed-type shackle pins, preferably using the special centring gauges obtainable from Messrs. Morris Motors. Care must also be taken to see that the shackle pins do not turn when the nuts are replaced on their ends and tightened up. Full details concerning the assembly of these screwed shackles is given in the section dealing with the Morris Eight (Series " E "), to which you are referred.

During reassembly, which is carried out in the inverse way to removal, use should again be made of the supporting jack and cranking bar to facilitate replacement of the components.

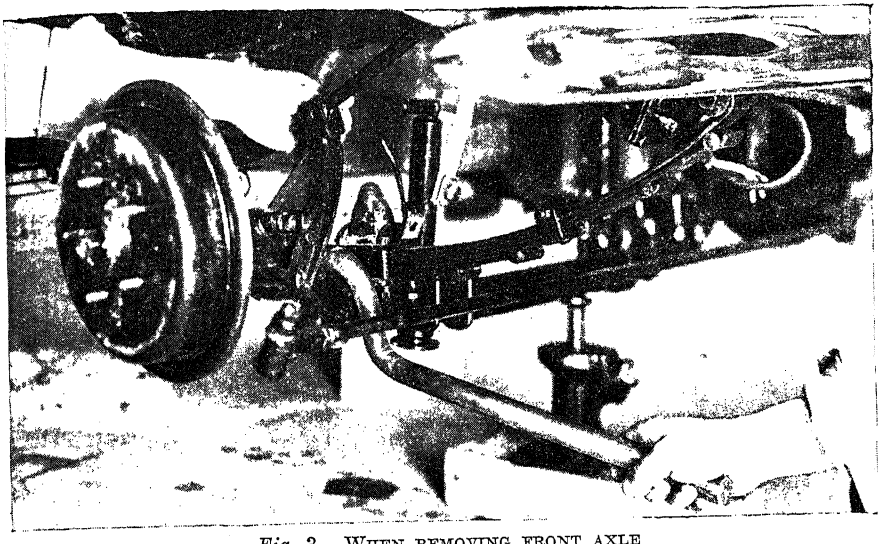


Fig. 3.—WHEN REMOVING FRONT AXLE

The use of a " setting iron " is necessary to relieve the torsion arms of the stabiliser from load while its attachment pins to the axle brackets are removed.

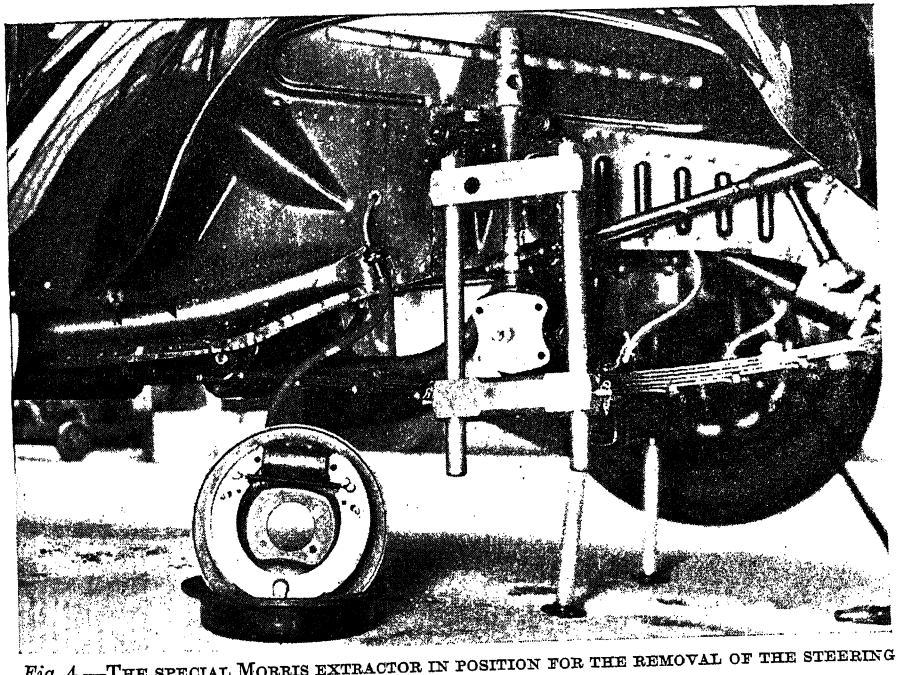


Fig. 4.—THE SPECIAL MORRIS EXTRACTOR IN POSITION FOR THE REMOVAL OF THE STEERING KNUCKLE PIN

Renewing the Steering Knuckle Pins and their Bushes

Attention may be given to the steering knuckles without removing the axle from the frame if the following procedure is followed, and use is made of the special extractor designed for this purpose by Morris Motors Ltd., and obtainable from their spare parts department under Part No. 55418.

The front wheels should first be raised clear of the ground and a firm stand placed under the axle.

The wheels should next be removed, and the brake drums withdrawn after their three retaining countersunk-headed screws have been unscrewed.

Remove the hub-retaining nuts from the ends of the axles, remembering that the offside nut is screwed with a right-hand thread but that the nearside nut is provided with a *left*-hand thread, and therefore has to be unscrewed in the opposite direction to normal. This will release the lock washers, and allow the felt oil-retaining washers to be withdrawn also.

A standard hub extractor should now be utilised to withdraw the hub from the axle, complete with the bearings distance-piece and inner oil retainer.

The brake backplates, complete with shoe assemblies, should now be removed by extracting the split-pins and nuts from the steering bolts, together with the nuts and spring washers from the bolts attaching the backplate to the axle flange.

The brake backplates should be carefully removed and placed on the ground in such a way that the Lockheed hydraulic brake pipes are not twisted or strained. There is no necessity to disconnect the pipes if the backplate assembly is handled carefully, and some support for the backplate may be found advisable.

Remove the nuts from the steering-pin cotters and withdraw the cotters. Remove also the $\frac{5}{16}$-in. setscrew and dust cap from the upper end of the pin.

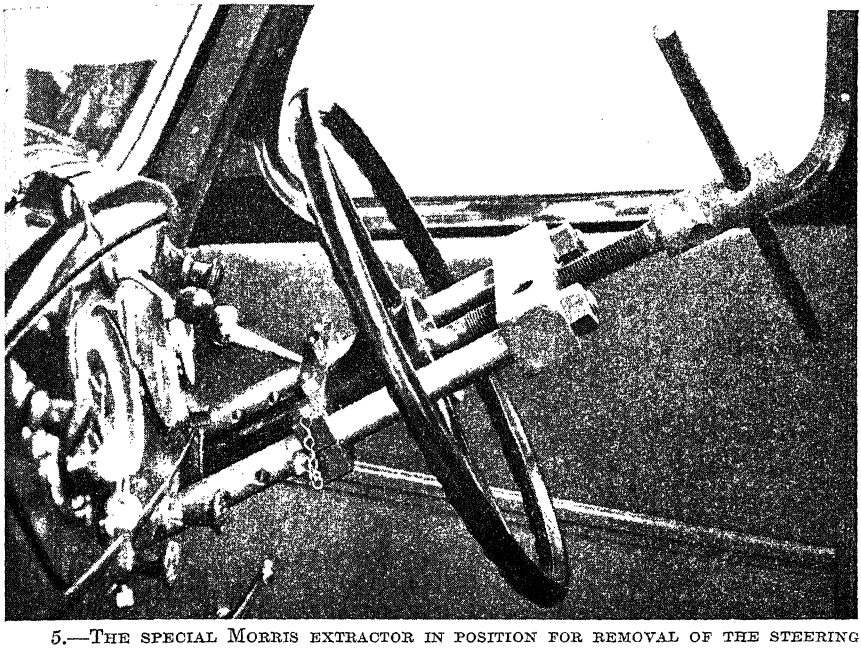
The special extractor should now be placed in position on the top of the steering pin, so that the pin may be pushed out in a downwards direction.

Driving out the pin in this way will automatically force out the dust caps from the bottom end of the steering pin, and these should be retained for refitting on reassembly.

The bushes in the axle are easily removed when necessary either in a suitable press or by the usual method of partly sawing through them, but when replacements are fitted it is essential that they should be reamered out with the special Morris reamer, Part No. 67193, to ensure a proper fit, as the act of forcing them into position contracts them slightly.

Removing the Steering Wheel

The steering wheel is removed from the steering column by releasing the cables from the bottom steering gearbox cover, as described in the



5.—THE SPECIAL MORRIS EXTRACTOR IN POSITION FOR REMOVAL OF THE STEERING WHEEL

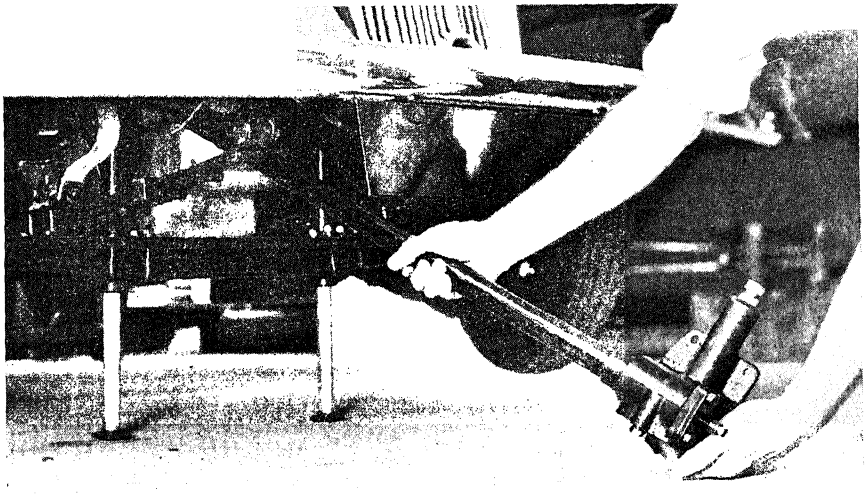


Fig. 6.—REMOVING STEERING-COLUMN ASSEMBLY

When released and the steering wheel removed, the steering gearbox and column can be withdrawn forwards and downwards, as indicated, if the rocker shaft is turned towards the nearside of the car.

section on "Balancing the Trafficator Switch" (*see* Vol. IV.), and driving the stator tube into the car some 2 or 3 in. in the same way.

This enables the cheese-headed clamp-screw of the switchbox to be released, enabling the switch assembly complete with cables to be withdrawn from the stator tube.

The stator tube is then pushed back into the steering column, and the steering-wheel retaining nut is removed with a box spanner.

A suitable extractor should now be employed to withdraw the steering wheel from the column, and that already described for steering-pin removal is quite satisfactory, namely, the special Morris extractor Part No. 55418 when used with the special steering-wheel attachment Part No. 56052.

Replacement of the parts is effected in the reverse manner to their removal, using a draw wire to pull the cables through the stator tube and making sure that the trafficator switch is correctly set, as indicated in the section dealing with this item.

Removing the Steering-column Assembly

The trafficator switch, switch cables, and steering wheel should first be removed, as indicated in the sections dealing with these operations, not forgetting to disconnect the battery positive terminal.

Remove the supporting bracket for the columns from the dashboard by unscrewing the two nuts from the attachment bolts.

Remove the pinch-bolt passing through the slotted end of the drop arm, and withdraw the drop arm from the steering gearbox spindle.

Unscrew the two setscrews attaching the gearbox to the underside of the offside dumb-iron, and the two which pass through the front-spring bracket.

This releases the steering-column assembly, which can now be pushed upwards into the body a sufficient distance to allow of its rotation so that the rocker shaft points towards the nearside.

The complete steering-column assembly can now be lowered again and withdrawn from the front end of the car if it is raised a short distance from the ground.

When reassembling the drop arm on replacement do not forget to make quite sure it is replaced correctly on the steering gearbox spindle, with the mark on its boss coinciding with the mark on the end of the spindle.

RADIATOR REPAIRS

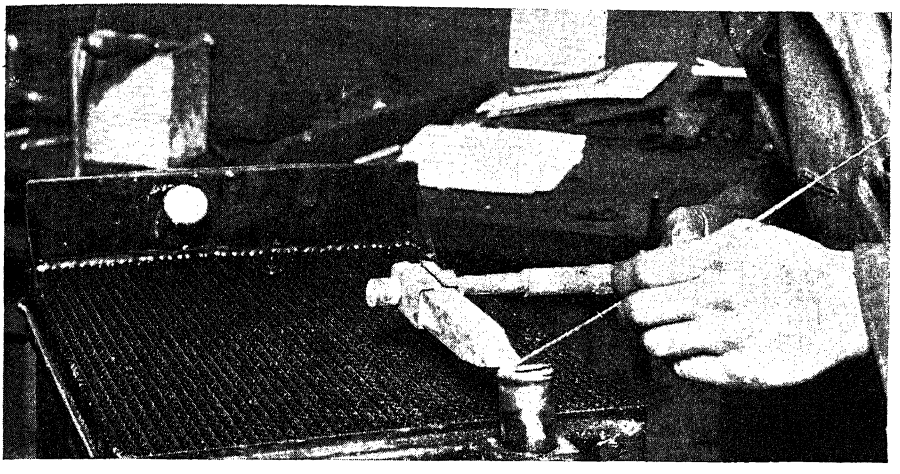


Fig. 1.—To locate leaks it is necessary to make an air-pressure test

The first thing to do is to seal up the water connections by cutting circular discs of tinned iron to the exact size of inlet and outlet pipes and the filler neck and then sweat them on as shown.

THE job of repairing a leaking radiator is one usually handed to a specialist repairer. This would, however, not always be necessary if the owner or garage mechanic were provided with more information concerning the construction of a radiator and the use of the soldering-iron and methods of testing.

Tools Required

It is proposed to deal first with the preparation of the necessary tools required for the job. A clean soldering-iron of an average weight of $1\frac{1}{2}$ lb. is needed. It is useless attempting a radiator repair with the light soldering-iron that one associates with a wireless set, as insufficient heat would be retained.

Tinning the Soldering-iron

The soldering-iron should be thoroughly cleaned by heating to a dull red, and the nose, or face, of the bit filed to the correct shape, i.e. an acute rectangular point with flat sides. The filing under heat is necessary in

order to remove all traces of pitting and saturation of the copper by tin. When the face of the bit is filed perfectly clean and bright, the nose of the bit should be dipped or rubbed in soldering flux or sal ammoniac, a small amount of solder applied from the stick, again dipped into the solution or flux, when a clean tinned face will be obtained. The best solder to use should contain not less than 60 per cent. tin and the remainder lead, usually known as tinman's solder. It is preferable to make use of an electric bit, as the heat being internal and constant the face does not become affected as by heating with gas or with a naked flame. Alternatively, an ordinary bit can be heated over a fire or gas flame to the required temperature.

Testing the Iron

To test the iron, it should run the solder readily without showing a trace of red heat. If an overheated bit is applied to a section of radiator tubes, it is quite within the bounds of possibility to crumple them, as solid copper will retain a far greater heat than the thin tubes of the radiator will withstand.

The Blow-pipe and its Uses

In the hands of a practised mechanic the gas blow-pipe is of great value, as it is almost impossible to repair a leak midway in the tubes with the soldering iron. This blow-pipe must be of such a design as to give a fine gas flame approximately the size of a lead pencil, and of 2 in. or 3 in. in length.

It is not suggested that an amateur should experiment on a radiator, using a flame of this description, without some previous experience. It would not be unusual, if the flame were applied for too long in one place, for a section of the tubes to collapse.

Points to Remember

Two great points to remember when carrying out a repair are, one, that the average thickness of the tubes of most radiators is ·005 in., necessitating somewhat delicate handling, and, the other, cleanliness in the whole operation. Soldering bits, flux, and any small cleaning tools should be perfectly clean. The metal to be soldered must be perfectly clean and free from grease or any foreign matter, otherwise a failure is likely.

TESTING

The method of testing applies to any make of radiator. The radiator, for the purpose of satisfactory test and identification of the leak, should be removed from the car and swilled inside with clean water, preferably warm, to remove silt and lime deposit as much as possible.

How to locate Leaks—the Air-pressure Test

Circular discs of tinned iron, such as can be cut from the average cocoa tin, should be cut the exact size of inlet and outlet pipes and the

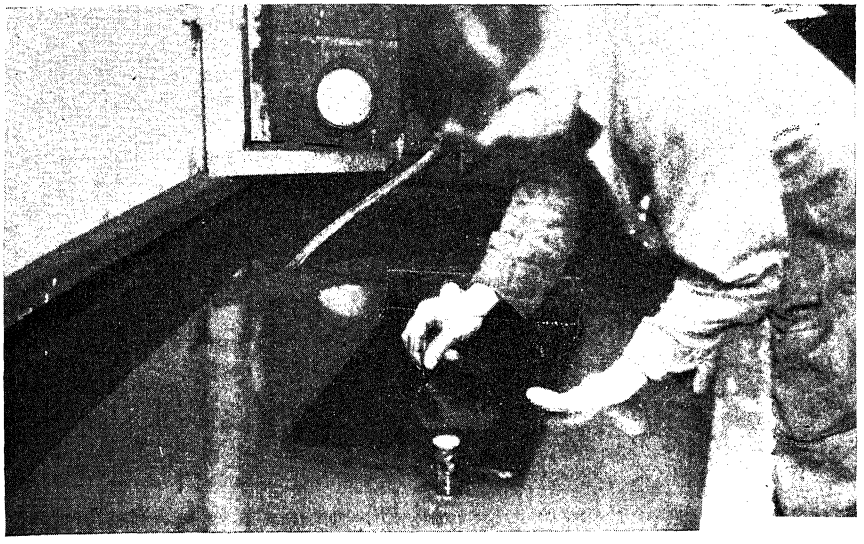


Fig. 2.—THE AIR-PRESSURE TEST BEING CARRIED OUT ON A RADIATOR

A piece of rubber connected to a tyre pump is attached to the overflow and the radiator immersed in a tank of water. Pressure is generated in the radiator, which will then emit bubbles at each of the various leaks. Tiny clips of thin metal should then be pressed over the particular spots where leaks are found so that they can be identified.

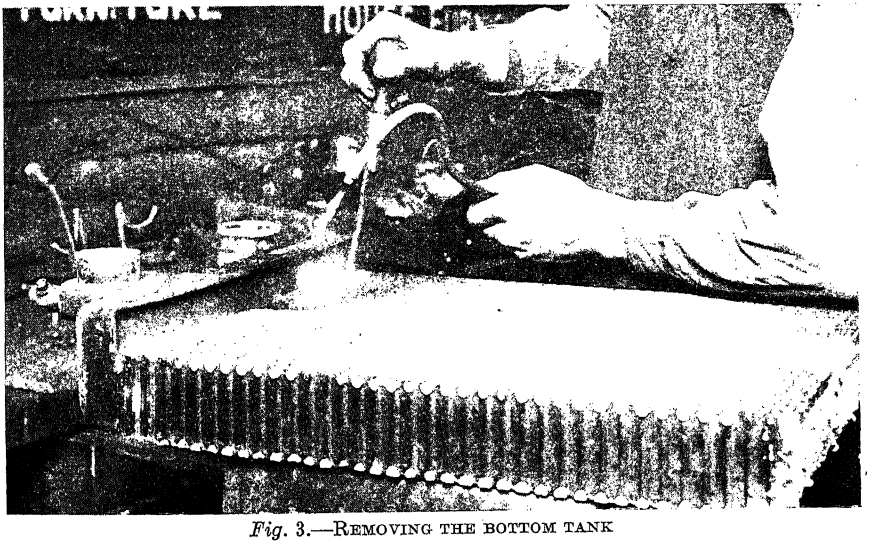


Fig. 3.—REMOVING THE BOTTOM TANK

A gas torch is being used as shown. Great care must be taken to apply the heat exactly and only where required, in order to avoid damaging the soldered joints on the face of the radiator block.

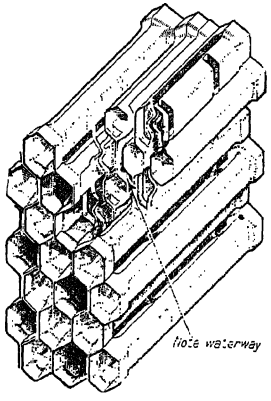


Fig. 4.—SECTION THROUGH HEXAGON-FILM BLOCK

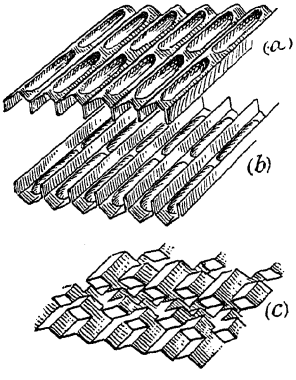


Fig. 5.—SHOWING THE CONSTRUCTION OF THE HEXAGON FILM

(*a*) and (*b*) show brass stamped to form waterway when sealed, and (*c*) cracked brass interleaf.

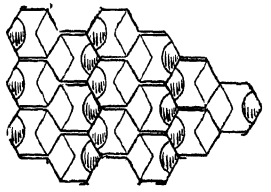


Fig. 6.—END VIEW OF HEXAGON FILM

filler neck: these should then be soundly sweated on. To the overflow should be attached a piece of rubber tube, connected to a tyre pump, and the radiator immersed in a bath or tank of water. By working the pump, pressure will be generated in the radiator, which will then emit bubbles at each of the various leaks. The largest will become apparent first.

Small U-sections of tin or other thin metal can be cut in the shape of tiny clips to be pressed over that particular spot where the leak is identified.

It will be found that when a radiator is leaking badly in many places, it is unwise to attempt to repair more than a few leaks at a time. If it is attempted to identify too many, memory fails in fixing the exact spot.

The Water Test

It is usual, after the radiator passes a satisfactory air-pressure test, to subject it to a hot and cold water test as well. Frequently a tiny crack or fracture in the soldered seam, although not discovered under air pressure, will be evident if the filler-neck cap is removed, the radiator stood in a leaning position, first filled with very hot water, allowed to become thoroughly hot, drained off carefully from the drain plug and immediately filled with cold water, which sets up contraction in the metal, and, if allowed to stand, will then perhaps show further small leaks.

THE FILM-BLOCK TYPE OF RADIATOR

This is the commonest type of radiator. Top and bottom tanks are fitted direct to the tubes, which is known as the core. This has the appearance, when viewed from the front, of a series of sections of corrugated brass placed together to form the necessary shape. A loose demountable shell is afterwards fitted.

At first appearance these corrugated sections appear to be simply one thin sheet of metal, but if closely examined it will be seen they are actually two thin pieces of metal first corrugated, the ends slightly offset, which, when placed together, leave an aperture between, through which the water can circulate.

Some of this type are built into the outer shell in such a manner that the whole, including the shell, is removed as one unit. The centre, complete with top and bottom tanks, can then readily be removed from the shell by removal of a small number of bolts and nuts. It is always advisable to remove the core from the outer shell before even attempting to test, to protect the finish of the shell from scratches or the effect of any solution that may be used in a repair.

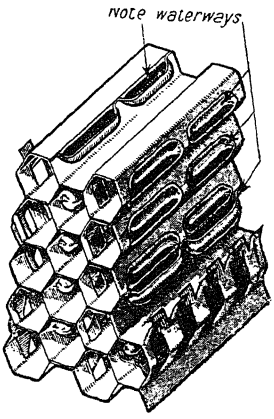


Fig. 7.—SECTION THROUGH FILM BLOCK

Temporary Repair on the Road

In the case of a leak occurring in the plain-film block whilst the car is on the road, it is sometimes possible, if the definite spot where the leak is can be identified in the tubes, to plug between the leaking spot and the neighbouring tube by inserting a thin piece of rubber tube and afterwards pressing into the rubber tube a small piece of wood, cut and shaved to the required shape to a push-in fit. Care must be taken not to exert too great pressure nor to insert the wood without a soft substance between the wood and tubes, or they may become perforated by the wood.

Do not use Putty or White Lead Stopping

In no circumstances is it wise to attempt to plug a section of leaking tubes with putty, white lead, or any substance which hardens, as once this has become solid in the tubes it is practically impossible to remove. Consequently, a new block would eventually be required. Should rubber tube be unavailable, if the radiator is drained, soap can sometimes be used as a plug with satisfactory results, and this can afterwards be quite easily removed by hot water when a permanent repair is to be effected.

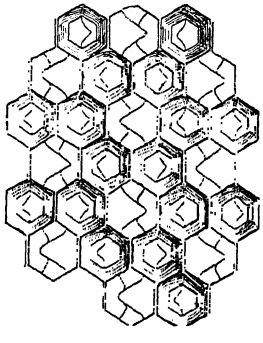


Fig. 8.—END VIEW FILM BLOCK

Method of Repairing Film-block Type Radiators

In a more extensive repair when possibly four or five tubes are affected, it can be decided under test whether the leak is at the joint of the tubes

on the face of the block. If so, these leaks are fairly easily repaired by cleaning thoroughly, applying some of the flux, and using the soldering-iron carefully in the usual manner.

Cleaning

If leaks are in the depth of the block the operation of repair is obviously a more difficult matter. It is fairly easy to clean through the tubes by means of the small wire brush, or even by scraping with the end of a small piece of brass wire. As a gas flame is essential to remedy this defect, it should not be attempted without previous experience of the gas flame.

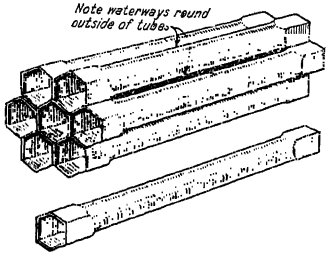


Fig. 9.—HONEYCOMB-TUBE SECTION WITH SINGLE TUBE OF SAME

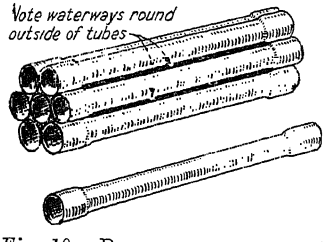


Fig. 10.—ROUND TUBE AND SECTION OF SAME ASSEMBLED

How to Blank Off a Faulty Tube

If it is a matter of urgency and the repair must be made, the easier way is definitely to identify and trace the leaking tubes from the bottom of the block to the top, cutting an opening in the top and bottom tanks sufficiently wide to expose the top and bottom of the tubes. The tubes can be cleaned at the inlet aperture at the top and the outlet at the bottom, and a small piece of brass wire inserted in the aperture, which can then be soldered into position, thereby blanking off the particular tube. This operation must be carried out at both top and bottom to be effective ; if only the top is sealed, the water will find its way up the tube from the bottom and the original leak will still remain.

When it becomes necessary to seal the end of the tubes, rendering them inoperative, it is distinctly dangerous to deprive the radiator of more than 15 per cent. to 20 per cent. of its original cooling capacity.

Subsequent to the sealing of the tube, the holes cut in the top and bottom tanks can easily be sealed by thin brass or copper sheet. On no account must tinned iron be used for this purpose.

If the Leak is between a Water Joint and Tank

Should the leak, on testing, prove to be between the seat of one of the water joints and the tank, this can sometimes be repaired by careful cleaning without the removal of the joint ; but whenever possible it is wise to remove the defective joint, to permit of proper cleaning.

The usual procedure, when the joint is riveted to its tank, is to cut the

existing rivets, replacing them, when the joint and its sealing have been properly cleaned and tinned, by small brass thread screws and nuts of an appropriate size.

To attach the nuts to the ends of the screws when passed through the holes in the joint, in some cases it is possible, where the joint is straight and large enough, lightly to sweat the nut to a piece of wire, passing it through the joint to its required position, when the screw can be inserted. The joint should then be heated, to run solder at its seating, and sufficient added to make a strong joint.

In the case of a water joint of an awkward shape it is usual to cut a small hole in the tank of the radiator in a convenient position, just large enough to allow the nut when attached to the piece of wire to be passed through. When attached to its screw and pulled tight it will be found easy by a twisting motion to detach the wire from the nut. These small holes can afterwards be sealed.

Dealing with a Faulty Overflow Pipe

One curious complaint that occasionally develops is the inability of a radiator to maintain its water level above a certain distance below the top of the overflow pipe.

If this is the case, it can usually be accounted for by a perforation, split, or crack in the overflow pipe below its top level and before it emerges from the tank. The only cure is to remove the pipe, which is a straightforward job, and replace by sweating in a new one, or by sweating or soldering the crack. Care should be taken when fitting a new overflow pipe or replacing the old always to attach the water-level end to the inside section of the filler neck. This can be effected by inserting the soldering-iron through the filler neck or by the application of a small flame. The outlet end should also be attached to some section of the block to prevent vibration. Either end left loose will vibrate and leak within a short time where soldered to the tank.

THE INTERLEAVED-FILM BLOCK TYPE

The interleaved-film block is built up in exactly the same manner as the plain-film block, with the addition of a thin, flat, copper strip inserted between each tube. This has the effect of increasing the efficiency of a cooling element by about 15 per cent.

It is somewhat more expensive to produce and, owing to the thin strip of copper between each set of corrugations, becomes somewhat more difficult to repair.

The method of repairing is exactly the same as for the plain film, but requiring somewhat more skill.

HONEYCOMB CRACKED INTERLEAVED-FILM BLOCK TYPE

This block is a film-tube block, but, when viewed from the front, has the same appearance as the older type of honeycomb proper, and was first produced in America. It has been manufactured in this country for some years and has become popular.

Repair

The finished article has a better appearance than the plain or the interleaved film and has excellent cooling efficiency, but is considerably more expensive to manufacture and more difficult to repair. Owing to its peculiar construction the repair of this particular block when leaking is not recommended for any but an expert.

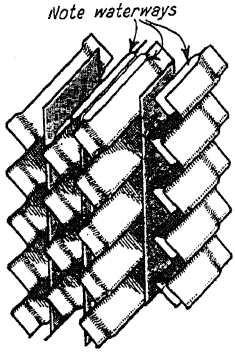


Fig. 11.—SECTION THROUGH SERCK INTERLEAF DIAMOND FILM

Testing

The method of testing is exactly the same, and repairs can be made in the same manner as in a plain-film block. Identification of a leak is rather more difficult owing to the corrugated interleaving, which is cracked and corrugated in two directions.

This block has an excellent record in durability unless subjected to external impact or ill-usage.

THE VERTICAL-TUBED BLOCK TYPE

Of this there are various types. The one most likely to be the subject of repair is the straight, horizontal-grilled, vertical-tubed type.

Construction

This type is composed of a top and bottom plate, perforated with holes the size of the tube to be inserted, and an appropriate number of tubes the length that the height of the block is intended to be are then inserted. Before insertion in the top and bottom plates, a series of thin copper, or in some cases iron, sheets perforated in a like manner are threaded to the nest of tubes, which then have the top and bottom plates attached, being properly tinned and sweated.

Locating a Leak

The radiator of this description, when leaking, should be the subject of the usual test. Evidence of the leak will become apparent in the same manner. If in the tubes, it will be necessary to separate the horizontal gills by means of a screwdriver to ascertain the exact spot where leaking, which can then readily be cleaned, tinned, and easily soldered.

A Caution

If the leak is between the tube and its top and bottom plate at the joint, it is unwise to attempt to repair this from the outside, as, although outside repairs of this nature possibly prove temporarily successful, the heat applied to the particular leak impoverishes the solder of the surrounding tubes to such an extent that in a short time the leak may become magnified.

Method of Repair

If it is intended only to repair one tube, a section should be cut from the tank and the tube repaired from the inside. If it is intended to resolder the whole of the tubes over one plate, the tank should be removed by unsweating at the seams, when the whole of the tubes and plates through which they pass can be cleaned and resoldered.

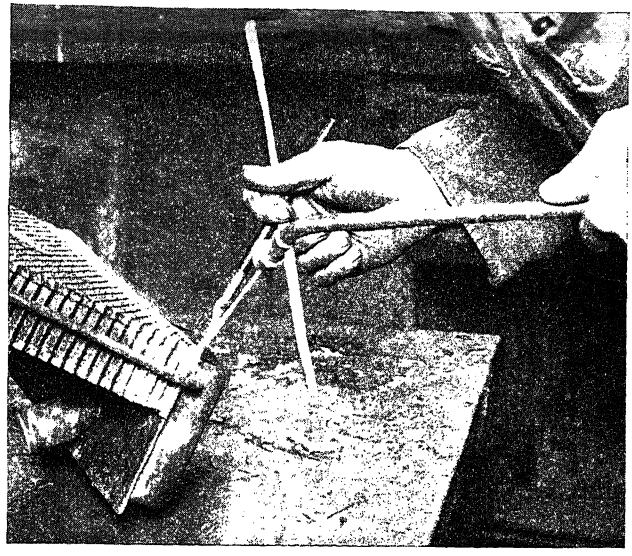


Fig. 12.—FITTING A TOP TANK
Showing how use is made of a gas blow-pipe.

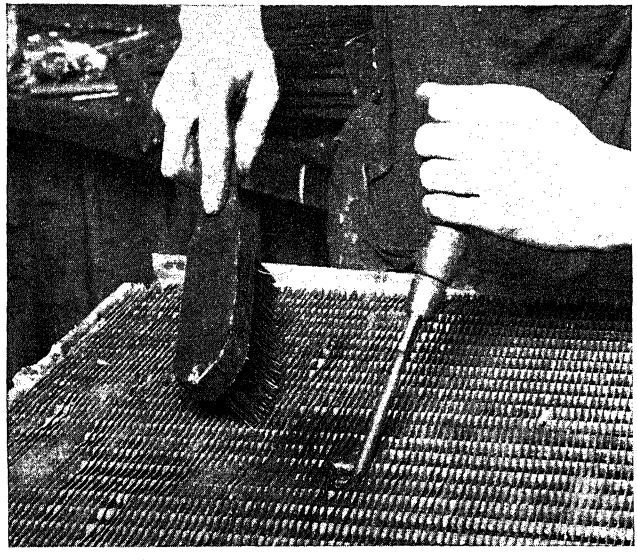


Fig. 13.—OPENING THE GILLS OF A VERTICAL-TUBE BLOCK
If a leak is found in the tubes it will be necessary to separate the horizontal gills by means of a screwdriver to ascertain the exact spot where it is leaking, which can then readily be cleaned, tinned, and soldered.

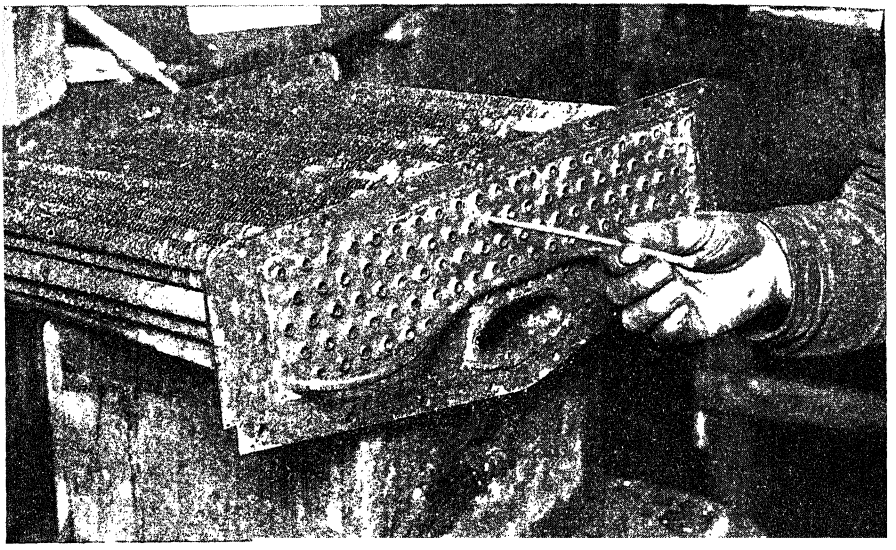


Fig. 14.—WHERE A VERTICAL TUBE IS LARGE ENOUGH AND HAS BECOME FRACTURED IT IS SOMETIMES FOUND EASIER TO FIT A LENGTH OF TUBE THROUGH THE ORIGINAL TUBE AS A LINER, SWEATING IT UPON THE PLATE AT EITHER END

This becomes necessary only where it is impossible to remove the damaged tube, or when a new tube is unobtainable. This makes a much more satisfactory job than blanking off the damaged tube.

In the case of demountable top and bottom tanks, which are usually of cast aluminium bolted to a fairly substantial plate, these can be removed without any damage occurring by the removal of the holding bolts ; the tubes are then accessible.

There are various types of vertical tubes in addition to the straight horizontal gill. Some are fitted with square gills stamped from small sections of thin tinned iron. There are also round and spiral gilled tubes. The manner of repair of these is the same.

Fitting a Liner inside a Damaged Tube

Where a vertical tube is large enough and has become fractured, it is sometimes found easier to fit a length of tube through the original tube as a liner, sweating the same upon the plate at either end. This becomes necessary only where it is impossible to remove the damaged tube, or when new tube is unobtainable.

The individually gilled tube is more generally used on heavy commercial vehicles.

THE HONEYCOMB-BLOCK TYPE

Of this block there are various types—round, hexagon, and square—in appearance resembling the honeycomb, doubtless from which this type

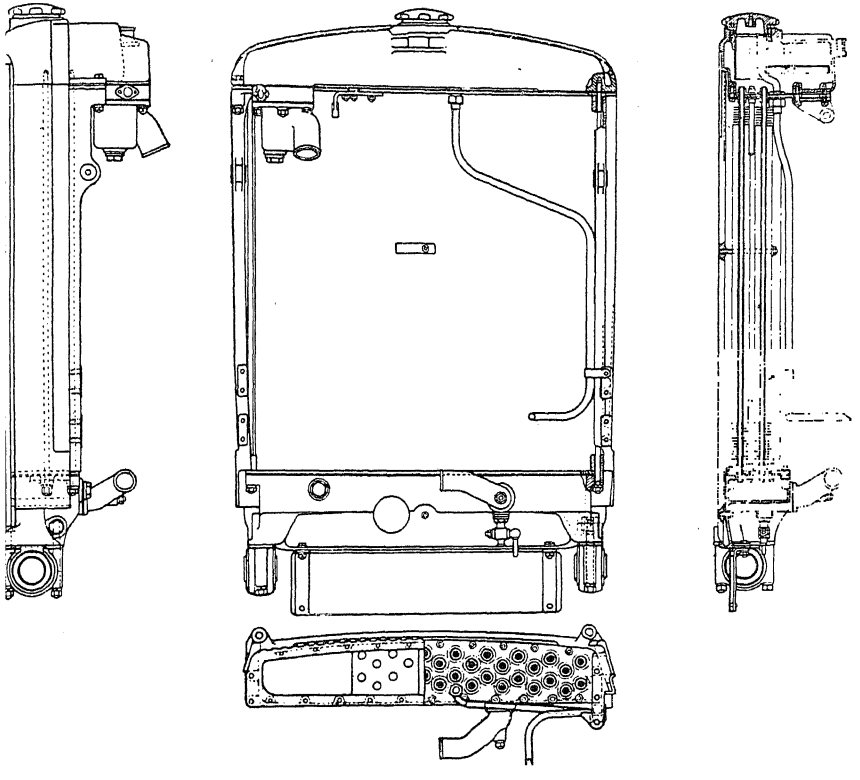


Fig. 15.—VERTICAL-TUBE TYPE OF RADIATOR (*A.E.C.*)

derived its name. At the time of its introduction it was the best and most efficient radiator. Owing to the cost of production it has become more or less obsolete, except in some of the more expensive cars.

Construction

This block is composed of a series of small drawn-brass tubes, in length the thickness of the block. Each tube has its end slightly expanded ; for assembling, the tubes are built into a frame closely packed side by side. When the frame is packed to completion it is clamped tight to the tubes, which are then dipped into a molten bath of solder on both faces, soldering the end of each tube to its surrounding neighbours.

The finished block is built into its tanks in exactly the same way as the film block if fitted to a demountable shell.

Method of Testing and Repair

For the purpose of repair the method of test is exactly the same as for the film or vertical tubed type. The identification of a leak is a rather

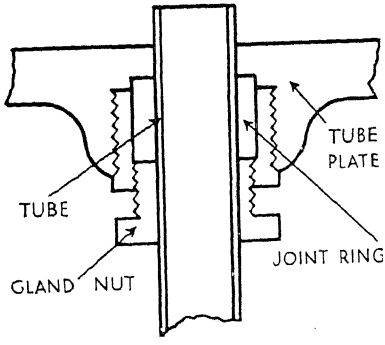


Fig. 16.—SECTION OF TUBE-GLAND OF RADIATOR IN FIG. 15

Leakage at the gland can be remedied by either tightening down the gland nut or, if this is not effective, by replacing the rubber gland.

more simple matter. Marking is made in the same way as for the film type; the difference is in the repair.

Should a surface leak be apparent by the application to the leaking spot of a soldering flux and careful cleaning, a repair can usually be effected in a short time with a copper bit. If it happens that a tube has become burst by frost, or perforated by the application of a heated soldering-iron to either end of the tube at the same time, or the flame of a fine gas blow-pipe blown through the tube, the defective tube can usually be removed and replaced by a new one, which is easily sweated in.

Owing to the scarcity of these radiators and the credit which must be given to them for durability and efficiency, the likelihood of a repair becoming necessary is rather remote.

One curious difference between the film or vertical tube and the honeycomb tube is that in the film or vertical the water passes inside the tube; in the honeycomb it passes outside. When viewing the honeycomb block from its face one is actually looking through the inside of the tubes.

STRAIGHTENING, CHECKING, AND ALIGNING FRONT AXLES

THE influence on the steering performance of a front axle out of alignment through even a slight impact is dealt with in Vol. I, under " Diagnosing and Correcting Steering Troubles." Where any doubt exists, this alignment should be checked. If difficulty is experienced in making these checks with the front axle in position, it will be necessary to remove the axle from the chassis, in order to check for alignment. On the other hand, a front axle may have been damaged to such an extent that the mal-alignment is quite apparent.

Removing Axle from Chassis

The fixing is usually obvious, the usual attachment being by the means of U-clips forming a yoke across the spring, passing through the tables of the axle, fitted with locknuts, nuts, and spring washers, or split pins, each of which are quite visible and easily removed.

The chassis frame must first be raised sufficiently high to take all weight off the front wheels, and securely supported in that position, the front wheels removed from the axle, and boxes or other supports placed in a convenient position so that when the U-bolts are completely released, the axle does not fall to the ground.

Attention is required to the braking system, as this must also be detached. With direct or servo braking, the detachment is an easy matter. With Lockheed brakes, the tubes should be carefully detached and the ends tied upwards to prevent as little of the fluid becoming wasted as possible.

The axle can then be entirely removed and placed in a vice or on a bench for examination and checking.

Before placing in the vice, the unit should be first thoroughly washed and cleansed of all mud, grease, etc., in a paraffin bath.

Dismantling the Axle

It is difficult to check a front axle without dismantling the brake gear, and it is always advisable to dismantle entirely, removing the brake gear and the king-pins.

Checking the Stub Axle

Whilst dismantling, if a king-pin appears unduly tight, the yoke of the stub axle should also be carefully examined, and when possible the

stub axle placed between centres or V-blocks to check the truth or otherwise of the spindle.

If Axle Beam is obviously Bent

The axle beam is next given attention. At the end of this article, the methods of finally checking the alignment of the axle beam are given. These methods can now be applied to the beam to find the amount of correction required. With a beam that is bent badly enough to be obvious, it will be unnecessary to commence testing until some straightening has taken place. Axles that are badly bent are often damaged to such an extent that straightening is not advisable, in which case it is always better to advise the owner to have a new axle fitted.

Correct Angle of King-pin Holes

For the purpose of ascertaining the correct angle of the king-pin holes, it is always best to make use of a makers' chart if obtainable. It seldom occurs, however, that both side angles become distorted—usually one is obviously unaffected. The angle of this side should be recorded by a protractor before any heat or straightening is applied.

Straightening Bent Axle Beam

The bend should be located carefully and chalk-marked at each extreme, an anvil or weight prepared upon which the beam is to be placed when heated, and a strong vice securely fixed in such a position that it is accessible and well lighted. The affected part of the beam should be heated to not more than a dull-red heat, placed in the vice, and forced by pressure to its correct shape. Should a press be available for this operation, its utility can be fully understood. So far as possible, blows with a sledge-hammer should be applied with great care. The heating should not exceed a dull red—just sufficient to allow the metal to be straightened.

First bring Spring Tables into Alignment

If the unit is affected between the spring tables, as well as between one spring table and a king-pin hole, straightening should commence from the centre, first bringing into correct alignment both spring tables, dowel-pins, and U-bolt holes. When checking the U-bolt holes it will be necessary to examine the front-spring alignment to find if the springs are parallel or have a taper fitting. The amount of taper can be ascertained by measurement, comparing the difference in width of the front knuckle joints and the rear shackles where the front springs are anchored to the chassis frame and working out geometrically the angle of the spring tables.

Then Straighten and Align Axle End Extension

The alignment of the tables must be carefully carried out and proved before proceeding to straighten the axle-end extension. When this

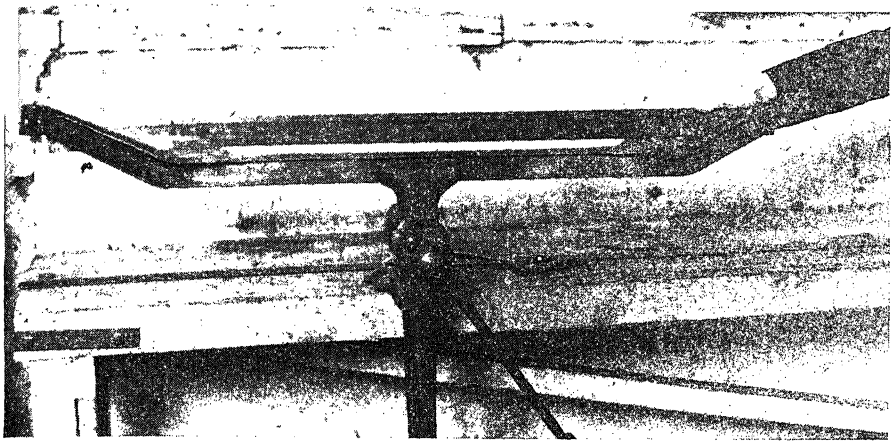


Fig. 1.—THE FIRST CHECK FOR ALIGNMENT
A straight-edge placed across the spring tables should lay quite plane.

operation has been completed satisfactorily, place the axle in the vice and ascertain the exact treatment that is required to restore the defective extension to proper alignment. To do this, a straight-edge placed across both spring tables and a trammel rod fitted to both king-pin holes, a protractor set to the unaffected side and then tried to the bent section, will indicate the amount of correction required to bring into alignment. A sight-line taken across the trammels will reveal any defect in vertical alignment. This will enable the operator to gauge more correctly the amount of pressure required to restore the affected part to normal.

Treatment after Straightening

When the beam has been restored to satisfactory alignment, it should be heated generally throughout and laid in ashes or sand to prevent chilling, and allowed to cool gradually and evenly, and never quenched in water.

A Word with Reference to Heat-treated Axles

It is a modern manufacturing process to subject front axles to a special heat treatment in order to toughen the metal and increase its tensile strength.

An axle so treated should, when possible, be returned to the makers to be subjected to their special method of heat treatment. Although a previously heat-treated axle may be satisfactorily straightened, there is an element of risk that in a subsequent impact a fracture may occur, or the nature of the metal may become impoverished and soft. Heat-treated axles can invariably be recognised by having a small section usually

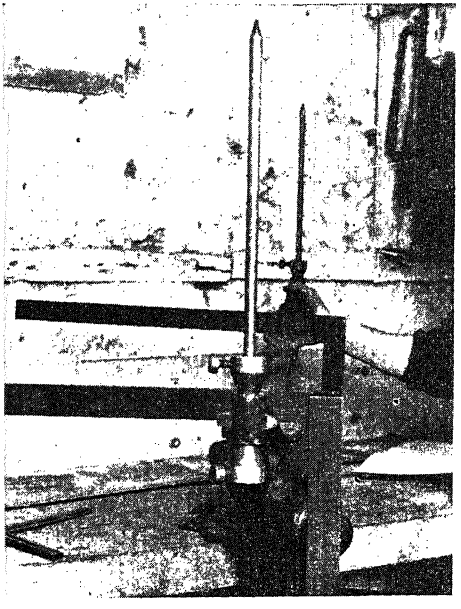


Fig. 2.—CHECKING ALIGNMENT OF SPRING TABLES AND KING-PIN HOLES

The horizontals of spring tables are checked by sighting the tops of the two straight edges with a square laid across each. This also shows checking verticals of king-pin holes by inserting special rods with taper sockets attached and sighting from end of axle beam.

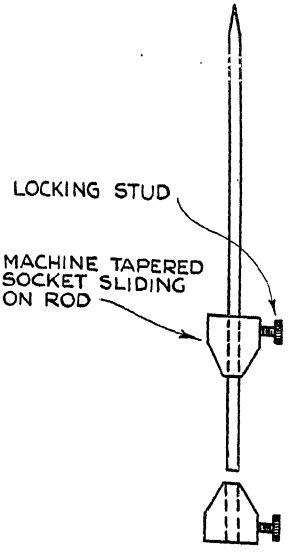


Fig. 3.—KING-PIN TRAMMEL OR TESTING PIN

The sockets which slide on the rod are conical to bring the rod central in king-pin hole when sockets are pushed together and studs locked.

in the beam between the tables ground flat and several small round marks driven in. These marks are inflicted under the Brinell test to which the axle is subjected by the manufacturers after heat treatment. As mentioned on page 312, it is safe to straighten axle beams cold if the metal has not been stretched to any extent. A magnetic tester will immediately show up any incipient cracks or flaws which may exist (*see* Figs. 22 and 23, pages 310 and 311).

Straightening a Slightly Bent Beam

A slight bend in a light-car front-axle beam can be rectified without the application of great heat, and can be straightened without disturbing the effect of previous preheating.

It is always necessary to remove the chill from the metal throughout the whole length of the beam, including spring tables and king-pin sockets. Preferably, the necessary pressure should be applied by a press.

If, however, a press is not available, by careful blows with a sledge-hammer and the beam placed on an anvil the rectification can be effected satisfactorily. In order to preserve the surface of the metal before striking with the hammer, place upon the affected spot a blacksmith's set hammer if procurable, or an ordinary piece of bar-iron to take the blow—which will prevent bruising of the surface.

Defective Stub Axles

When dismantling the stub-axle ends, if one king-pin is troublesome to remove and much tighter than its opposite member, it is possible that the yoke has become damaged. This defect is not one that can easily be rectified, and a replacement stub axle can safely be recommended.

Where damage to a stub axle has been sustained by impact on a wheel or hub centre, the spindle should be tested as recommended, and if found defective, provided the defect is only of a slight nature, can sometimes be satisfactorily straightened by a skilful operator. This operation, however, requires powerful and accurate machines, and should not be undertaken except under exceptional circumstances. It is not in any case advisable if a replacement unit can be procured economically.

Defective King-pins

When a stub axle is proved to be bent in the yoke, it will be obvious that the king-pin will also be affected. The pin has invariably a ground and polished finish, and is case-hardened ; it can confidently be recommended that bent king-pins should under no circumstances be straightened and put into service.

It is a good practice before erecting a renovated axle to examine the king-pins and stub-axle spindles, although apparently undamaged, for possible cracks. These parts, being bright, after being thoroughly cleaned and immersed in paraffin, then removed from the paraffin bath, wiped dry, and cleaned with a petrol rag to render the surface of the metal dry and bright, will, if smartly tapped with a mallet or light hammer, reveal cracks, if any exist, by exuding paraffin which has penetrated into them.

FINAL CHECK OF FRONT-AXLE BEAM BEFORE ERECTING

The surface of the spring tables, vertical alignment of the king-pins, and the angles of the pins must all be carefully checked and proved correct before commencing to reassemble the axle. Checking may be done in the following manner :

Spring Tables

Place the axle again in the vice, laying a long straight-edge lengthwise across both spring tables at the same time. Look between the straight-edge and the spring tables with the eyes at the same level, holding a sheet of white paper behind the straight-edge, which will render any error in alignment visible (Fig. 1).

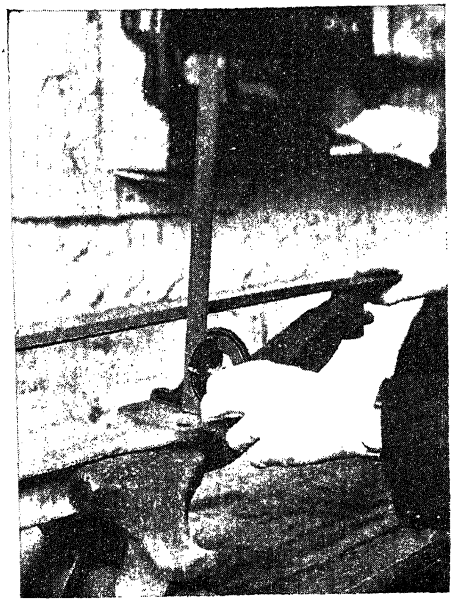


Fig. 4 (*left*).—TESTING ALIGNMENT OF KING-PIN AND DOWEL-PIN HOLES

Straight-edge laid flat and set at centre of king-pin holes. Protractor set at 90° touching straight-edge with square point at centre of dowel pin hole.

Next, take two shorter straight-edges or squares of a sufficient thickness to support themselves and lay each crosswise over the spring tables, taking a sight-line from the end of the axle to check the horizontal alignment of the tables (Fig. 2). Subject to this test proving satisfactory, proceed with the check.

Axle-end Extension and Dowel- and King-pin Holes

Place the long straight-edge across the top of both king-pin sockets, taking a measurement down from the lower edge of the straight-edge to the centre of the spring table to prove the rise of the axle extension between the spring table and the king-pin socket (Fig. 6). Next, turn the straight-edge flat on to the king-pin socket with one edge across the centre; place a small square on the spring table, with its edge to the centre of the dowel-pin

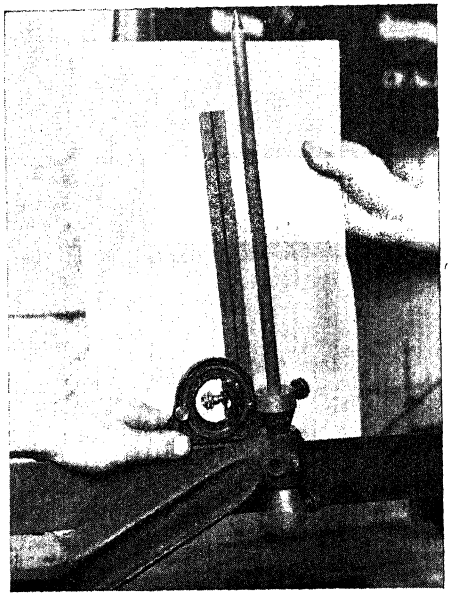


Fig. 5 (*left*).—TESTING ANGLE OF KING-PIN HOLE

First set protractor at correct angle, place straight-edge across both tables and insert rod through king-pin hole. The protractor is placed on the straight-edge and white paper is held upto throw edges into greater relief.

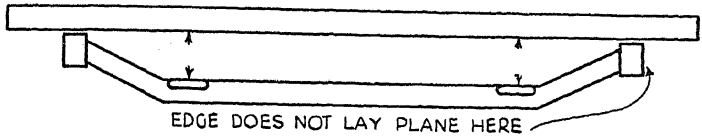


Fig. 6.—MEASURING RISE OF EXTENSION FROM SPRING TABLE TO KING-PIN SOCKET.

The straight-edge does not, of course, lay flat on top of the socket, owing to the angle at which the pins are set.

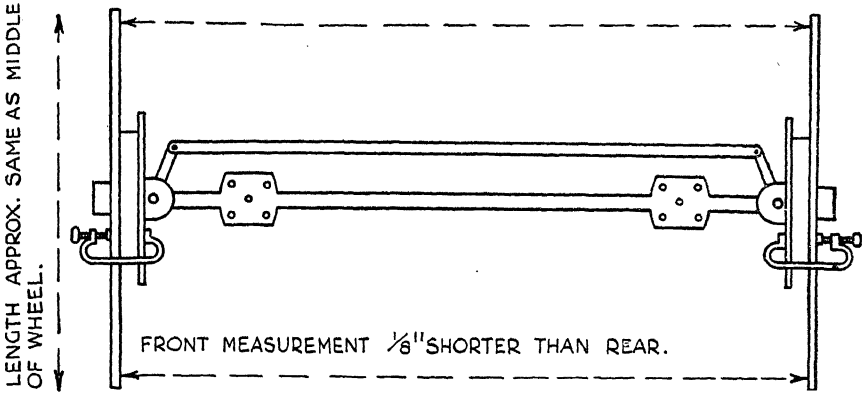


Fig. 7.—CHECKING FRONT-WHEEL ALIGNMENT BEFORE FITTING AXLE TO CHASSIS BY CRAMPING STRAIGHT-EDGES TO FACE OF HUBS AND MEASURING EACH SIDE.

The above example indicates a toe-in of ⅛ in.

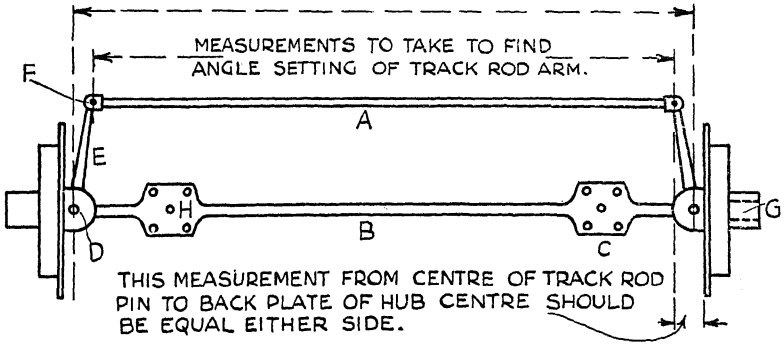


Fig. 8.—LAY-OUT OF TYPICAL FRONT AXLE.

A, Track rod. *B*, Axle beam. *C*, Spring table. *D*, King-pin. *E*, Track-rod arm. *F*, Track-rod pin. *G*, Stub axle. *H*, Dowel-pin hole.

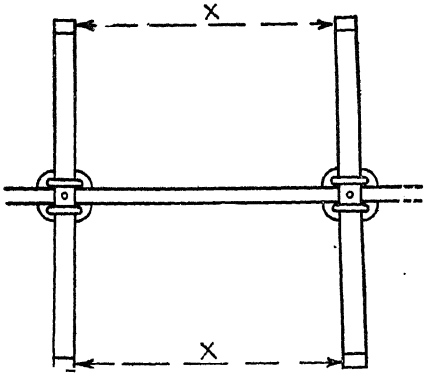


Fig. 9.—PLAN OF FRONT SPRINGS

Set at an angle to show measurements to take to ascertain angle at which spring tables should be.

hole, to prove that the centre of the dowel-pin holes and the king-pin holes are in alignment (Fig. 4).

Angles of King-pin Sockets

Finally, but not the least important, is a determination of the angles of the king-pin sockets. This must be checked from two positions, the spring table and the socket itself. Place the trammel bars securely in the sockets, lay the long straight-edge lengthwise across the spring tables, set the protractor to the axle end which was unaffected, taking care that this setting is correct, using the sheet of white paper to throw the line of the trammel bar into greater relief, and, when a maker's chart is available, the degree of angle should be carefully registered and checked against the chart (Fig. 5).

Reverse the protractor and place in the same position on the opposite side of the beam to test the angle of its fellow-member.

To ensure accuracy, then place the straight-edge across the top of the king-pin sockets and check the angles again by the same method. If this is incorrect, it indicates that the rise of the extension is not right.

REASSEMBLING

After accidental damage and the subsequent restraightening of a front-axle beam, it is assumed that prior to the damage the front-wheel track was in normal alignment. When commencing to reassemble the repaired parts, they should re-erect freely and without undue force, each part being greased and carefully lubricated during the operation. If force is necessary to any parts, these parts should be the subject of careful examination.

Checking Track-rod Arms

Before refitting to the car, the condition of track-rod arms needs attention. These parts are subject to fracture and damage which may easily escape detection. All paint should be removed and the arms scraped clean and tested for cracks in the manner recommended for king-pins and stub axles. When proved undamaged and reassembled in position, the track rod should be carefully examined and track-rod pins subjected to the same inspection.

It is modern practice to fit straight track rods which are at times

provided with an adjustment. This adjustment is not intended to overcome malalignment, but to correct minor errors of a fractional nature.

Preliminary Checking of Front-wheel Alignment

With the axle fully assembled, the front-wheel alignment can be checked before fitting to the chassis, as it may be necessary to make some alteration in the setting of a track-rod arm. Completely assemble the unit less the front wheels only. Retain the beam firmly in the vice, take two sections of wood approximately the length of the diameter of the wheels, and cramp or fix them to the hub firmly across the face, balancing them in such a manner that they remain in a horizontal position. Set both hubs parallel, in the position they would be if attached to the car and steering straight ahead, taking an exact measurement between the rear end of each wooden straight-edge and comparing with the front (Fig. 7)

Usually, where the parts are in good condition with no visible wear, the frontal measurement should read not more than $\frac{1}{8}$ in. short. If this measurement is abnormal, the track-rod arm attached to the damaged side should be carefully examined. The position of a track-rod arm is not in any sense haphazard, and has a direct relationship to the angle upon which the wheels turn when on the lock. Measurements taken from the track-rod pin hole in the arm to the brake-drum cover will usually reveal a discrepancy and indicate which arm is at fault—each side should be exactly equal.

Alternatively, take a measurement between the centres of the king-pin holes and another between the centres of the pin holes in the track rod, which will be found the shorter of the two. Divide this measurement equally on each side, and the degree of angle on each track rod compared with the stub axle can be confirmed.

Setting of Track-rod Arm

The setting of a track-rod arm should be carried out with the same care as an axle, and as little heat as possible is applied. These parts are as important and susceptible to fracture as any part of the unit, and should therefore be treated with the same care and attention as any other.

Subject to the axle passing the recommended examination and test, the next operation is to refit to the chassis frame.

Refitting Axle

No special attention is required when refitting an axle to a car fitted with direct or servo braking system except to make sure that all bolts are in good condition, well tightened, fitted with strong washers or split-pins, and that the brakes are adjusted in the usual manner.

With the Lockheed system of braking, the brakes will need bleeding. This operation must on no account be overlooked. It is quite a simple

operation provided the operator has the proper bleeding nipple and tube for the purpose. (*See* section on "Lockheed Brakes.")

Check Wheel Alignment

Finally, attach the wheels and spin them to ascertain that the brakes are free and that the wheels have suffered no damage and are running true before removing the supports and placing the car upon the ground. Also, check the front wheels for alignment, taking measurements between the fronts of each rim and between the rears by the means of trammels specially designed for the purpose, setting the trammels carefully as near to the centre of the wheel as possible, chalk-marking the rim where checked, passing the trammel underneath the car at the rear of the wheels, slightly raising the wheels from the ground, turning over until the chalk marks are in the same position in relation to the trammel as they were when checking the front. This test should give the same reading as the alignment test before fitting the axle.

Testing Lock

Next, raise the front wheels clear of the ground, turn on to one extreme lock, taking a measurement from the inside of one rim to a chassis-frame front knuckle, reverse on to the opposite lock and take an opposite measurement, which should coincide within $\frac{1}{2}$ in.

If this measurement is unsatisfactory, an adjustment can invariably be made by setscrews provided for the purpose.

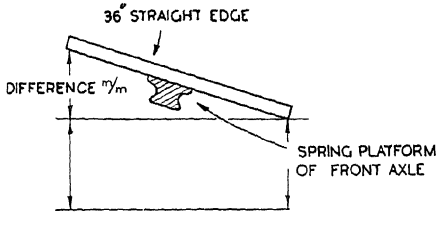


Fig. 10. (*left*)—THIS SHOWS A METHOD OF CHECKING THE CASTOR ANGLE OR BACKWARD INCLINATION OF AXLE AND KING-PIN.

The straight-edge must be 36 in. long, but need not be centralised on the spring platform. After the measurements have been taken, the angle can be obtained from the table below.

STUB-AXLE-PIN INCLINATION

Difference mm.	*Angle deg.*	*Difference mm.*	*Angle deg.*	*Difference mm.*	*Angle deg.*	*Difference mm.*	*Angle deg.*
4·00	$\frac{1}{4}$	43·18	$2\frac{3}{4}$	82·35	$5\frac{1}{4}$	121·36	$7\frac{3}{4}$
7·85	$\frac{1}{2}$	47·10	3	86·25	$5\frac{1}{2}$	125·22	8
11·73	$\frac{3}{4}$	51·20	$3\frac{1}{4}$	90·17	$5\frac{3}{4}$	129·14	$8\frac{1}{4}$
15·70	1	54·94	$3\frac{1}{2}$	94·07	6	133·02	$8\frac{1}{2}$
19·62	$1\frac{1}{4}$	58·36	$3\frac{3}{4}$	97·98	$6\frac{1}{4}$	136·90	$8\frac{3}{4}$
23·57	$1\frac{1}{2}$	62·84	4	101·88	$6\frac{1}{2}$	140·76	9
27·48	$1\frac{3}{4}$	66·69	$4\frac{1}{4}$	105·78	$6\frac{3}{4}$	144·66	$9\frac{1}{4}$
31·38	2	70·61	$4\frac{1}{2}$	109·68	7	148·54	$9\frac{1}{2}$
35·08	$2\frac{1}{4}$	74·52	$4\frac{3}{4}$	113·58	$7\frac{1}{4}$	152·66	$9\frac{3}{4}$
39·25	$2\frac{1}{2}$	78·43	5	117·47	$7\frac{1}{2}$	156·28	10

THE VAUXHALL FOURTEEN (MODEL "J")

WITH FURTHER NOTES ON THE TEN AND TWELVE

To Remove Radiator and Front-wing Assembly

WHERE it is necessary to remove the radiator and/or wings for attention to other parts of the car, a saving of time can be effected by the removal of both wings and radiator as an assembly on the Vauxhall Fourteen (model "J"), Ten-Four (model "H"), and Twelve-Four (model "I").

This is done in the following manner on the Fourteen, the procedure on the other models mentioned being almost the same. *Take care while doing so not to damage the front-brake hoses.*

Drain off the water from the radiator and disconnect the hoses. Remove the bonnet. Disconnect the side- and head-lamp leads at the push-in connectors on the right-hand wing valance.

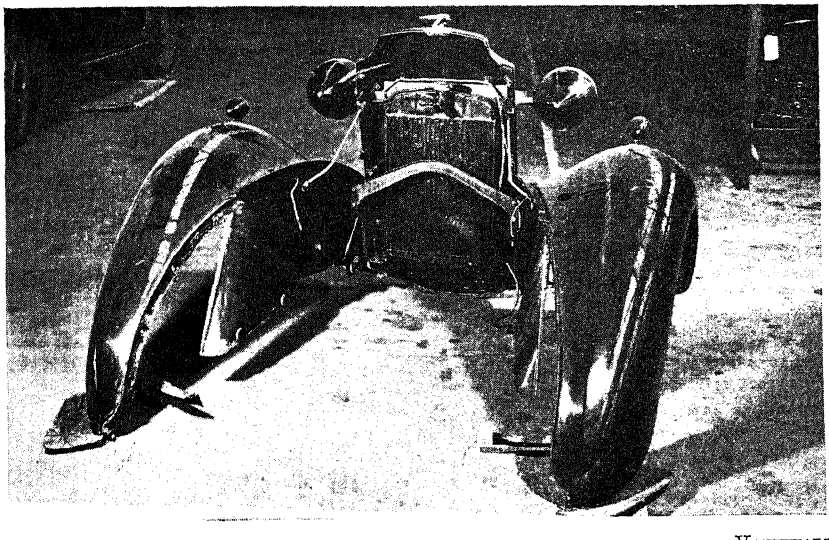


Fig. 1.—BOTH WINGS AND RADIATOR CAN BE REMOVED AS AN ASSEMBLY ON THE VAUXHALL 14 H.P., 12 H.P., AND 10 H.P.

The example shown is the assembly on the Ten-Four car.
(*By courtesy of Shaw & Kilburn, Ltd.*)

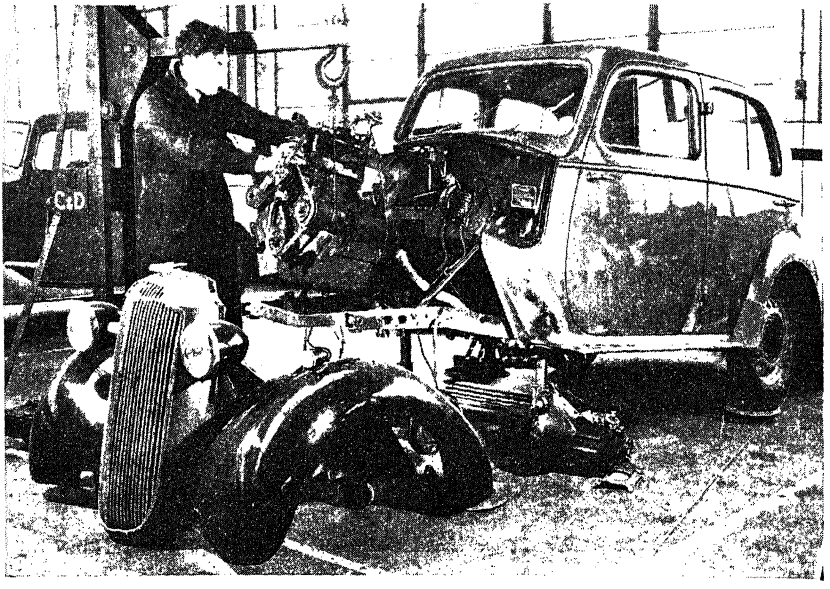


Fig. 2.—SHOWING EASY REMOVAL OF WINGS AND RADIATOR ASSEMBLY PRIOR TO DISMOUNTING ENGINE FROM SUB-FRAME (10 H.P.)

Remove the two screws which attach the wing valances to the frame side members; these screws pass through rubber insulated washers. Disconnect the wing stays at the point where they are attached to the inside of the frame. Remove the four bolts securing the front wings to the body on either side.

Remove the two bolts securing the front-wing and radiator-shell brackets to the front cross-member, taking careful note of the number of shims beneath each bracket.

Remove the screw at the front of the wings; this passes through a rubber insulated washer and secures the wing to the *inside* of the frame side member. The assembly can now be lifted away.

To replace, reverse the foregoing, ensuring that the same number of packing shims is fitted beneath the brackets.

To Remove Frame (Fourteen " J " model)

When it will be necessary to withdraw the frame on the Fourteen " J " model, in order to carry out repair work, this may be done by following the sequence of operations given below.

Remove the radiator and wings, engine and gearbox assembly, propeller shaft, and steering box.

Disconnect the main wiring harness, main petrol-feed pipe, and the

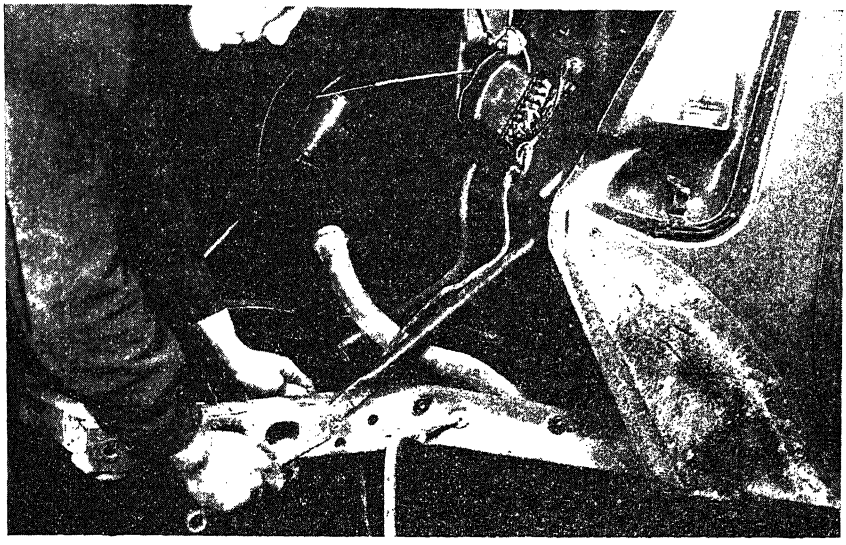


Fig. 3.—REMOVING SUB-FRAME ON THE VAUXHALL 10 OR 12 H.P.

Unscrewing bolt attaching diagonal body support to the sub-frame. Pull support sideways so that the spigot bush is drawn out of its hole.

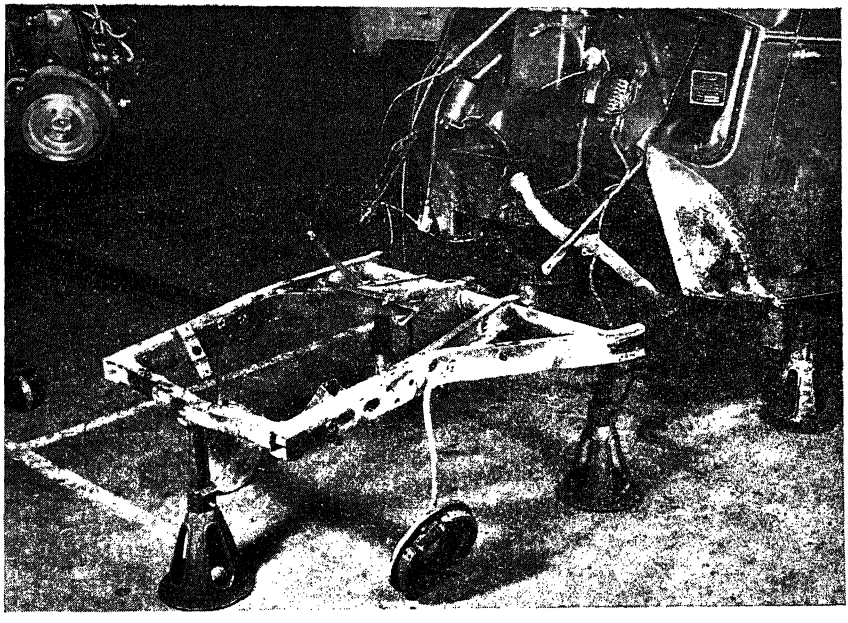


Fig. 4.—SHOWING SUB-FRAME DRAWN AWAY FROM THE BODY (10 H.P. AND 12 H.P.)

rear-brake feed pipe from the three-way connector on the rear axle and from the four-way connector on the rear cross-member of the frame.

Remove the pedal pads and stems from the pedal levers. Disconnect the speedometer cable from the clip on the frame, the handbrake front cable from the intermediate lever and from the bracket securing it to the frame, and the handbrake rear cables from the intermediate lever.

Remove the exhaust pipe and silencer assembly, and remove the two bolts securing the jacking brackets to either side of the frame and also the three setscrews attaching the brackets to the underside of the body; the brackets can now be lifted away.

Place supports beneath the front end of the body, then remove the ten bolts and setscrews which secure the frame to the body on either side. Remove the bolts attaching the two diagonal body supports to the frame and pull sideways, so that the spigot bushes are drawn out of their holes. The frame, complete with pedals, brake master cylinder and front-brake pipe lines, can now be drawn away from the body.

The Sub-frame on the Ten-Four and Twelve-Four

Removal of the sub-frame on the Ten-Four and Twelve-Four Vauxhall, which is secured to the forward end of the body below the scuttle by four bolts, two on either side, is carried out in similar fashion (*see* Figs. 3 and 4).

14-h.p. Independent Front Wheel Suspension

Disassembly of the front suspension simply for the purpose of checking is not recommended when universal front-end alignment equipment is available, as all checking operations can be carried out whilst assembled on the car with this equipment. For detailed notes on camber angle, pivot-pin inclination, caster angle, and toe-in, the reader is referred to the article in Vol. IV entitled "Diagnosing and Correcting Steering Faults."

Worn pivot pins or bushes, badly adjusted or worn wheel bearings, tend to give incorrect camber-angle readings, and therefore a true judgment as to the state of the front-suspension components—by which is meant the carrier arm and housing—cannot be obtained. Therefore, when an obviously completely worn assembly is noticed it is due for repair anyway, and should be proceeded with accordingly.

Alignment Angles

Toe-in . .	$\frac{3}{16}$ in.
Caster angle .	7°–8°
Camber angle .	0°–1°
Pivot-pin inclination	5°–6°
Included angle .	5°–7°

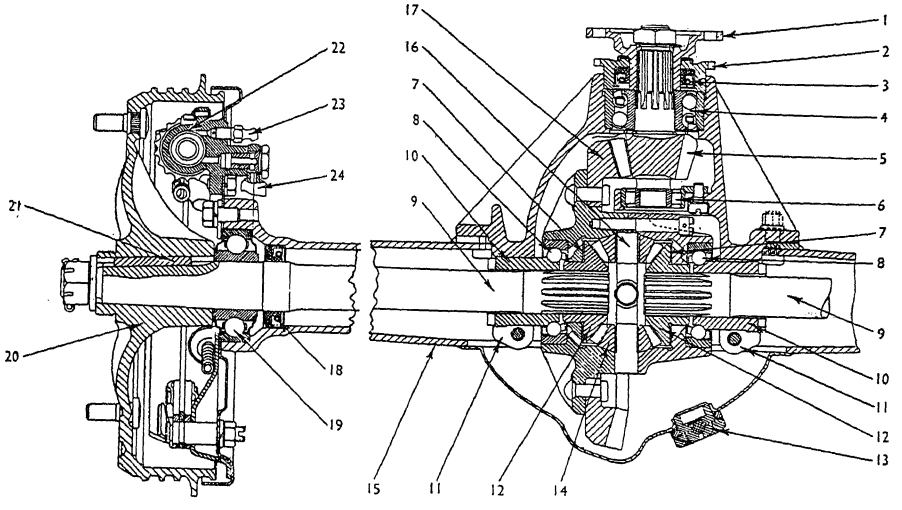


Fig. 5.—SECTIONED VIEW OF REAR AXLE

(1) Propeller-shaft Coupling Flange. (2) Pinion-adjustment Locking Ring. (3) Pinion Oil Seal. (4) Pinion Front Ball Race. (5) Spiral-drive Pinion. (6) Pinion Front-support Roller Race. (7) Differential Side Gear Thrust Washer. (8) Differential Ball Race. (9) Axle Shaft. (10) Differential Ball-adjusting Sleeve. (11) Differential-bearing Pedestal. (12) Differential Side Gear. (13) Axle-filler Plug. (14) Differential Pinion. (15) Axle Casing. (16) Differential-pinion Spider. (17) Spiral-drive Gear. (18) Axle-shaft Oil Seal. (19) Axle-shaft Bearing. (20) Rear Hub and Brake Drum. (21) Axle-shaft Key. (22) Brake-shoe Cylinder. (23) Brake-cylinder Bleeder Screw. (24) Brake Pipe-line. Connection.

Wheels and Tyres

Rim size . .	3–50 × 16 in.
Tyre size . .	5–50 × 16 in.
Tyre Pressures—Front	25 lb. per sq. in.
Rear	30 lb. per sq. in.

Incorrect Camber

If on checking it is found that the camber angle does not conform to the specifications, it will usually be found that the wheel carrier arm is bent and so needs replacement. Actually, this should not be decided upon until you have checked pivot-pin inclination.

Incorrect Pivot-pin Inclination

It is usual to consider the camber angle and pivot-pin inclination together, the addition of these two angles being termed the "included angle."

Now it will be seen that if, after making the checks on a car, the included angle is correct but that both camber angle and pivot-pin inclination are wrong, then the axle beam is bent or twisted.

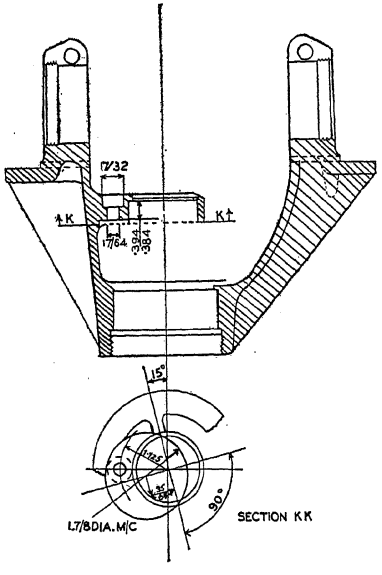


Fig. 6.—DIFFERENTIAL CASE-MACHINING INSTRUCTIONS

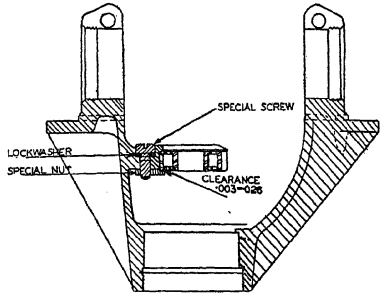


Fig. 7.—ASSEMBLY OF DIFFERENTIAL-PINION BEARING LOCATING NUT

If, however the pivot-pin inclination is correct and the camber angle wrong, then the wheel carrier arm is bent, the housing being of such stiff construction that it is practically impossible for it to distort.

Incorrect Caster

When the caster angle is found to be incorrect, either—

(*a*) the axle is twisted ;

(*b*) the axle is not attached correctly to the frame ; or

(*c*) the frame is bent.

When it is found that the caster angle is incorrect to the same extent on both sides of the car, it is usually a simple matter to correct by shimming the axle beam.

A description of the Vauxhall independent front-wheel suspension system is given on pp. 62–70.

Alignment Data for 10- and 12-h.p.

Caster, 7°–8°

Camber, 1°–2°.

Toe-in, $\frac{3}{16}$ in. (This is recommended for the 10-h.p. as well as the 12-h.p. model. Originally a parallel setting was recommended for the 10-h.p. car.)

Pivot-pin inclination, 4°–5°.

Pivot Pins

If excessive clearance is evident between the pivot pin and bushes or between the bushes and the knuckle bosses, the steering efficiency will be impaired and the bushes should be renewed. Production clearances

for all models are : pin clearance in bushes, ·0005–·0018 in., and clearance of bushes in knuckles, ·0001–·0018 in., and when renewing parts these limits should be observed.

Check the condition of the thrust-bearing and also the up-and-down float of the knuckle, inserting the necessary shims on the top face of the knuckle to provide a clearance of ·003 in. (·076 mm.) maximum. Shims of ·005 in. and ·010 in. thickness are available when correction is necessary.

REAR SUSPENSION

The rear axle of the Vauxhall 14 h.p. is shown in Fig. 5. Rear axles on the 10 h.p. and 12 h.p. are dealt with fully elsewhere. On 14-h.p. cars with Chassis No. J.5451 onwards, the outer race of the differential-pinion bearing is retained by a special nut and slotted-head bolt. Whenever an axle is dismantled for service work the opportunity should be taken to incorporate this method of location in accordance with the machining details given in Fig. 6. The assembly of the bolt and location nut is shown in Fig. 7. It will be observed that ·026/·003-in. (·66/·076-mm.) clearance is allowed between the face of the bearing outer race and the special nut.

To Reassemble Rear Axle (14 h.p.)

It is essential that the pinion adjustment shims are positioned correctly, so that they are nipped between the casing and the outer race of the ball bearing when the locking ring is tightened.

Make certain that both the locking ring and universal-joint flange nut are tightened securely, as otherwise a false adjustment may be obtained.

To Adjust

With the assembly held firmly in a vice the gears can be inspected for mesh. Adjustments should be made to obtain full-length engagement of teeth, smooth running, and a backlash between the spiral gear and pinion teeth of from ·005 in. to ·007 in.

Adjustment for this is obtained by slackening one spiral-drive-gear adjusting ring and tightening the opposite ring until the minimum amount of backlash can be felt.

When it is apparent that the spiral-drive pinion is too far in mesh or insufficiently meshed, it will be necessary to remove the pinion and remove or add shims. The shims available are of ·003-in. and ·005-in. thickness, consequently a close adjustment is possible.

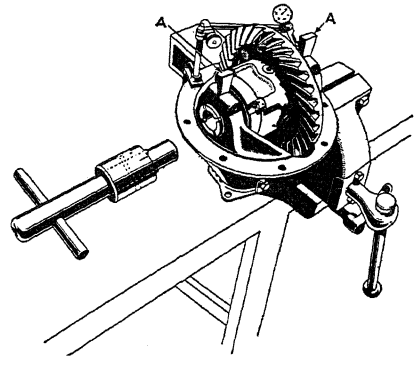


Fig. 8.—DIFFERENTIAL ASSEMBLY SET UP FOR PRELOADING BEARINGS

Note carefully that, although it has the appearance of an adjusting sleeve, no adjustment can be made by simply tightening or slackening the pinion locking ring: shims must be added or removed, and the pinion locking ring finally tightened prior to checking the new position obtained.

Carefully withdraw the pinion for the purpose of altering the number of shims, taking care not to damage the teeth.

Having satisfactorily completed the adjustment for backlash, that for tooth contact must be made.

It is absolutely essential to provide a load to the pinion shaft when rotating the gear. Without this it has been found that an adjustment can be obtained giving a marking which resembles correct contact, but which invariably results in a noisy axle when assembled. A sufficiently effective load can be obtained if a 4-in. diameter circular plate having rounded edges be turned and drilled for bolting up to the universal-joint coupling flange. This provides a comfortable grip for the hand. A brass plug with a $\frac{5}{16}$-in. S.A.E. thread should be screwed into the tapped drilling in the differential casing, so that the side and planet gears cannot rotate. In order to turn the spiral gear a handle should be made up and inserted to engage with the splines of one of the differential side gears.

For adjusting the teeth of the spiral-drive gears the reader is referred to the previous article, " Repair Notes on Vauxhall Cars," p. 169.

Preloading Differential Side Bearings

The final operation is that of preloading the differential side bearings to prevent deflection of the bearing pedestals under load, which would cause tooth-bearing variations. Preloading of the bearings became effective in production at Chassis No. JI.2435.

The extent of the bearing preload is 30°, and for accurate setting of the adjusting sleeves a special tool will be found necessary.

If the adjusting sleeves are excessively tight, taper wedges (*A*), Fig. 8, may be driven between the slots in the pedestals to ease the threads slightly.

Arrange a dial gauge to take deflection readings on the pedestal of the differential carrier on the spiral-drive gear side, as shown in Fig. 8. It is essential for the dial-gauge support to be clamped to the flange of the differential casing on the side opposite to the pedestal upon which deflection readings are taken, otherwise a true reading will not be obtained.

Now slowly tighten the left-hand sleeve (as viewed in Fig. 8) until movement of the pointer on the dial gauge indicates that the position has been reached at which the pedestals begin to deflect outwards. This is the point at which preloading begins, and must be carefully maintained during the next adjustment.

Slacken the left-hand differential-bearing adjusting sleeve (as viewed in Fig. 8) and tighten the opposite one *by exactly the same amount* until

the backlash between the spiral-drive gears has been reduced to ·001/·002 in. to allow for backlash increase during preloading.

Slacken the left-hand sleeve slightly and again determine the exact point at which preloading begins by noting the position at which the dial gauge begins to register deflection when the sleeve is tightened. Scribe a line on the left-arm carrier pedestal, as viewed in the illustration opposite one of the degree markings on the tool, taking up any slack between tool and sleeve before marking the pedestal. From this point tighten the same adjusting sleeve through a further 60° rotation, when the side bearings will be preloaded to the correct degree, and the backlash of ·005/·007 in. between the spiral-drive gear and pinion automatically restored.

Finally replace, and thoroughly tighten the clamp-bolts.

THE DAIMLER STRAIGHT EIGHT
(3½ LITRE)

By A. SQUILLARIO

Brakes

THE brakes are Girling mechanical type, vacuum-servo assisted, having a vacuum reservoir (*see* Fig. 1). A copper pipe (*D*) leads from the induction system to a non-return valve. From the non-return valve a pipe is led to the reservoir (*C*) and another pipe to the servo (*A*).

Removing Servo from Chassis

To remove servo from chassis, first disconnect pedal rod from brake pedal, and rear-brake rod from connection. Remove suction pipe and take care that joints are not damaged. Unbolt and remove servo from chassis. Note positions of bolts, etc., otherwise servo casing may be strained or distorted when bolted up to chassis.

Dismantling and inspecting Servo for Wear

Remove link-pivot pin and end cover, and withdraw piston assembly. Examine cylinder, piston, and all joints for wear. Thoroughly clean off all parts with paraffin, and dry carefully.

The piston leather should be carefully examined, and if not perfectly

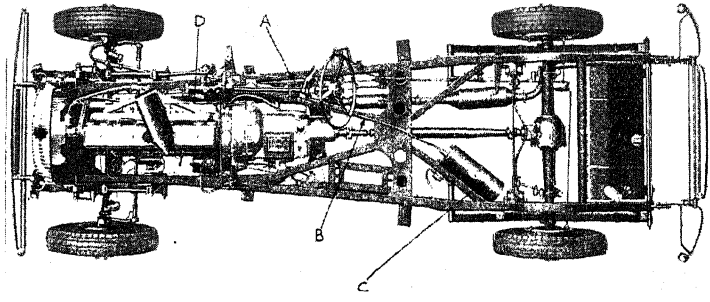


Fig. 1.—BRAKING SYSTEM

(*A*) Servo. (*B*) Pipe (reservoir to servo). (*C*) Reservoir. (*D*) Pipe (induction to non-return valve).

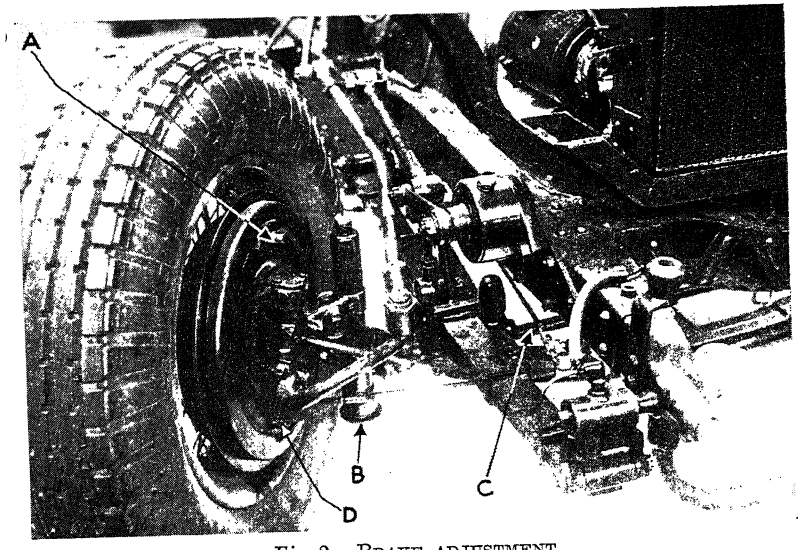


Fig. 2.—BRAKE ADJUSTMENT

(*A*) Brake adjuster nut. (*B*) Hydraulic jack. (*C*) Track rod. (*D*) Cone housing nuts.

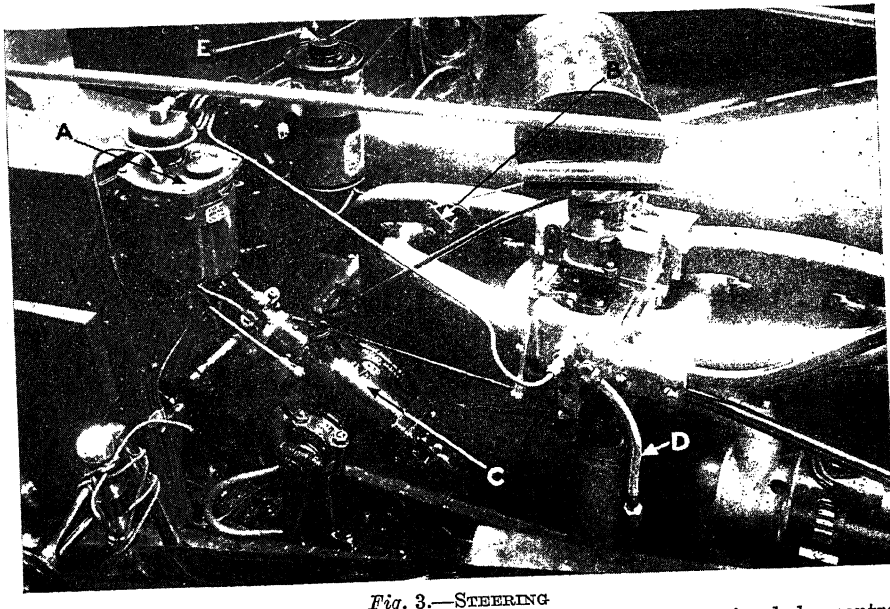


Fig. 3.—STEERING

(*A*) Oil container for automatic chassis lubricator. (*B*) Automatic choke control lever. (*C*) Burman-Douglas steering box. (*D*) Pipe to servo. (*E*) Hydraulic jack reservoir.

soft and pliable should be renewed. Inspect the hard brass expanding ring located underneath the leather. This should press the cup leather evenly on the walls of the cylinder. If it is not making even contact it may be slightly re-expanded. Although a fairly large working clearance is allowed on the piston, the cup leather must make good contact all round the bore to prevent leak.

Refitting Servo to Chassis

As stated previously, great care must be taken to see that the servo is not strained when refitted to the chassis. Before coupling up servo to brake pedal and brakes, see that both of these work quite freely and are well lubricated. A tight brake pedal will cause sluggish release of the servo as well as absorb braking effort.

After fixing servo to chassis, the rod coupling servo to brake pedal should be fixed, and great care must be taken to see that the levers in the servo are back in their rearmost position, *and the pedal is in its fully "off" position.*

This is of paramount importance, for the total travel of the servo should coincide with the total travel of the brake pedal. This point should be checked very carefully before the brake rod from the servo to the brake cross-shaft is attached.

The length of the rod between servo and brake pedal is of extreme importance, and once determined should never require alteration. *All adjustments must be made behind the servo.*

In refitting the suction pipe, see that a good leak-proof joint is obtained. With the exception of a few drops of oil in plug hole on top of servo, no other attention is required.

Adjusting Brakes

Adjustment of brakes is very simple. Tighten adjuster nut (*A*) (Fig. 2) as far as possible, slacken nut back a quarter of a turn (a click will be heard), and brake is then adjusted correctly. Repeat on each wheel.

Warning.—Do not tighten up the split cone housing nuts (*D*), as it is intended that the housing should be allowed to float to a limited extent.

Steering

Occasionally reports are received of erratic steering, commonly called "wobble." In most cases this has been a matter only of adjustment. All adjustments to the steering should be entrusted to a competent mechanic. Burman-Douglas steering is fitted.

Wheel Alignment

The toe-in should be from $\frac{1}{8}$ in. to $\frac{3}{16}$ in. These figures are absolute minimum and maximum respectively. These measurements should b

taken from the edge of the rim at wheel centre. To adjust, slacken locknuts at both ends of the track rod, and rotate track rod until correct adjustment is obtained, and tighten locknuts (*see* Fig. 3).

Caster angle should be 2°, and should not exceed 2½°. Offside and nearside should be checked, as a variation may exist between the two.

Special equipment is obtainable for accurately checking the caster angle, but if not available the following method may be used :

The angle can be measured by an inclinometer off the top of the swivel-pin bush. This must be done very carefully, as the actual surface available is so small, and a false reading may be obtained.

It is important that the wheel nuts are kept tight. A copper hammer is supplied in the tool-kit, and this should be used in conjunction with the wheel spanner to ensure that the nuts are *really* tight.

THE THORNYCROFT STURDY CHASSIS

CHASSIS TYPE ZE 5-TON (forward control)
YE 5-TON (normal control)

REAR AXLE

THE rear axle is of the fully floating overhead worm type, and transmits the driving thrust to the frame through the road springs. The rear spring clamping bolts must be kept screwed up tight, and it is advisable to examine them from time to time, more particularly during their early life, to make sure they are tight. The level of the oil in the axle casing should be verified occasionally, and brought up to the top of the filler plug. We advise users to clean out the casing, using a mineral flushing oil, and to refill with fresh oil every twenty thousand miles, or more often if convenient. A good quality gear oil is essential, about 1 gallon being required to fill to correct level. *Grease must on no account be used in the rear axle.*

Dealing with Oil Leakage along Axle Shaft

Oil leakage along the axle shafts is prevented by a spiral oil seal at the inner end of each axle sleeve. These are secured by a screwed dowel, which can be removed with a screwdriver when the worm-gear casing is lifted off. A gland, packed with impregnated felt, is fitted at the front end of the worm-shaft, but should oil leakage develop here the gland should be tightened just enough to prevent further leakage. Whenever an oil leak has been found, make sure that the oil in the axle casing is up to the correct level.

Parallel roller bearings are fitted to the rear-wheel hubs, and as these require no adjustment, little attention is needed other than lubrication. Should excessive play develop in the hub, it will be found that the bearings are worn, and a new set will have to be fitted.

The hubs should not be over-lubricated, otherwise the excess grease will be thrown on the brake drums.

Dismantling Rear Axle

When dismantling the rear axle, the worm-gear assembly, with differential, can be lifted complete with top cover, after the propeller shaft is uncoupled and the differential shafts are withdrawn. These need be

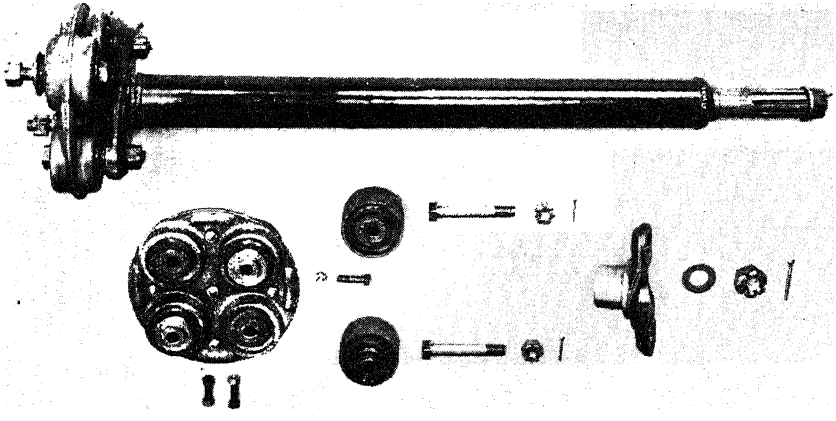


Fig. 1.—ASSEMBLY AND PARTS OF " YE " AND " ZE " PROPELLER SHAFT AND UNIVERSAL JOINTS

drawn out only about 6 in., and if the driving flanges stick when the eight bolts securing them have been removed, insert setscrews into the two tapped holes in the flange, and screw up evenly until the flange is parted from the hub. If the hubs are to be removed, first take off the hub cap and withdraw the differential shafts completely. Next take out the small bolt which locks the hub nut, and screw this nut off the axle sleeve. The hub and bearing assembly can then be withdrawn complete. When dismantling the hub, the oil retainer on the inner end must be removed before the bearing at that end can be withdrawn.

Gear-oil Specification

For the rear axle a good quality amber gear oil of medium thickness is preferable. Do not use a thick black oil.

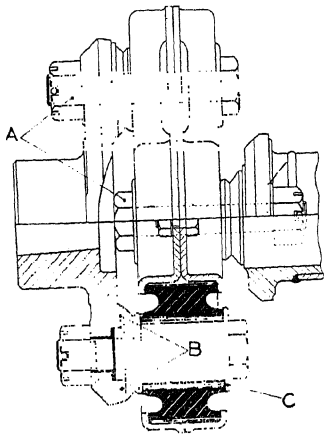
A suitable oil should have the following characteristics :

Viscosity at 140° F.	400–700 seconds.
Cold test	Not above 30° F.

This specification is approximately equivalent to S.A.E.140.

PROPELLER SHAFT

The drive is transmitted by a two-part tubular propeller shaft, which is supported at the rear end of the forward part by a roller bearing attached to one of the frame cross-members. The intermediate bearing should be lubricated with gear oil, the oil-gun nipple being located on the grease-nipple plate on the left-side frame member.



2.—PROPELLER SHAFT UNIVERSAL JOINT

Removing Intermediate Shaft

To remove the intermediate shaft, disconnect the oil pipe to the bearing housing, and take out the coupling bolts at each end. Undo the two bolts holding the intermediate-bearing support plate to the frame cross-member, and remove the shaft complete with bearing and bracket. Do not let the rear shaft hang down when the front end has been disconnected, or the rear coupling may be strained.

To Remove Intermediate Bearing

To remove the intermediate bearing, draw off the universal-coupling fork and take out the bolts fastening the bearing housing to the support bracket. The two halves of the bearing housing may then be parted. Take away the support bracket and draw the bearing off the shaft. The oil seals in the bearing housing should be renewed if worn, and the cork joint for each half-housing should be replaced if broken.

Check Universal-joint Bolts for Tightness

The coupling bolts (*A*) (*see* Fig. 2) should be checked for tightness occasionally. These bolts are made of specially tough high-grade material and will stand more than normal tightening. Use an extended length of spanner, if necessary, to bring the split hole in line with the slots in the nut.

If the bolts are not correctly tightened, the sleeves will rock, destroying the flat abutment faces (*B*), and no amount of subsequent tightening will rectify this.

If the couplings should be dismantled at any time, or in the event of new couplings being fitted, see that the washer (*C*) is assembled in the position shown, and not under the nut behind the companion flange.

Lubrication

All the brake-rod joints must be kept free and well lubricated, also the cross-shaft bushes. The pins of the joints must be oiled with an oil-can, but the cross-shaft bushes are fed from an oil-gun nipple on the grease-nipple plate attached to the left-side frame member. Take care not to over-lubricate the brake camshafts or hubs, as the excess oil may get on to the brake drums and adversely affect their stopping power.

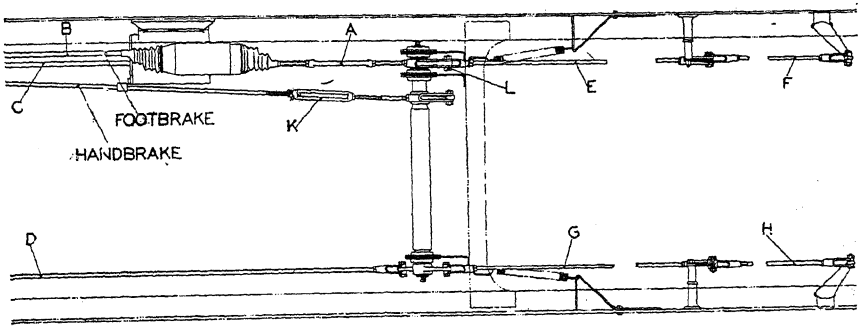


Fig. 3.—ADJUSTMENT OF BRAKES

When Relining Shoes

When all the adjustment on the brake lining has been taken up and it is necessary to reline the brake shoes, countersink the rivet holes deep into the brake-liner fabric, so that the head of the rivet is well below the surface of the fabric when fixed to the shoe. After riveting, file the brake liner to remove the burrs. The brake drums are mounted on the outside of the hub flange and retained by spherical seatings, so it is not necessary to disturb the hub bearings when removing the brake drum.

Greasy Brakes

If grease or oil has found its way into the brakes, this should be cleaned off with petrol. Greasy brakes generally indicate over-lubrication of the hub bearings, and to prevent this the quantity of lubricant injected into the hubs and brake camshafts must be reduced.

Adjustment of Brakes

As the hand-brake operates the same shoes as the foot-brake, it must be remembered that adjustment will be required, even when this brake is seldom used, owing to the wear caused by constant use of the foot-brake; and because of this it is the hand-brake which should be watched to determine when it is necessary to adjust the brakes.

Normal Adjustment

The foot-brake is assisted by a vacuum-servo cylinder, and operates on both front and rear axles. The leverage has been carefully arranged to give the maximum braking efficiency, and a quick adjustment of the brakes is provided by the turnbuckles (*A*) and (*K*) (*see* Fig. 3), and all adjustments for normal wear of the linings must be made here. Before the brakes have worn sufficiently to let the hand-lever up to the end of its travel, it will be necessary to adjust them. The hand-brake operates on all four wheels, and is connected to the same set of shoes as the foot-brake.

Rods (*B*), (*C*), (*D*), (*E*), (*F*), (*G*), and (*H*) (Fig. 3) are set to the correct length before leaving the manufacturers, and must not be altered except in exceptional circumstances.

To Rebalance Brakes

To rebalance, should this become necessary, put the hand-brake in the "off" position, pack the brake pedal down about 3 in., and adjust the turnbuckle (*A*) (Fig. 3) until the nearside rear-wheel brake is beginning to grip, giving the hand-brake turnbuckle (*K*) one and a quarter times the number of turns given to (*A*). Check off the offside brake, and, if necessary, shorten or lengthen the rod (*E*) until the drag on the offside wheel, when rotated by hand, is the same as that on the nearside wheel. To adjust rod (*E*), slacken off the locknut on the brake rod, withdraw joint pin (*L*), and turn the brake-rod jaw in the required direction. The front-wheel brakes should be balanced at the same time by slackening off the locknut on the front-brake rod and adjusting the jaw at either wheel.

Test for Unequal Temperatures of Driving

When next on the road after having made the above adjustments, test the brakes for balance, after a few applications of the foot-brake the temperature of the rear-wheel drums should be equal and the same applies to the front. Should this not be so, the cause may be due to oil or grease having found its way into one of the drums, and if this is the case the drums and linings must be thoroughly cleaned before retesting. If the rear-wheel drum is affected, the oil chute for draining away any excess lubricant from the hub should be examined to see that it is not clogged up, and less grease should be injected when subsequently lubricating the hub.

As the adjustment of the turnbuckles is taken up, examine the pull-off spring attached to the brake cross-shaft, and if the tension of the spring is increased unduly, move the spring-anchor bracket forward to the next hole.

Squeaking Brakes

Squeaking brakes are nearly always caused by uneven adjustment of the brakes. When the vehicle is jacked up off the ground, the brakes, when applied, should press evenly on all brake drums. If this is not the case, then they should be adjusted by the procedure indicated in previous paragraphs.

FRONT AXLE

The axle body is of I-section, and is forged in one piece. The stub-axle swivel pins are supported on tapered roller bearings, and an aluminium cover is fitted to prevent the intrusion of dirt and water.

The nuts on the spring holding-down bolts must be kept screwed up tight, and should be checked occasionally for any sign of slackness.

Little attention to the front-hub bearings will be needed beyond regular lubrication, as these are of the parallel-roller type, which do not require adjustment.

Worn Hub Bearings

If, after considerable use, excessive play should develop in the hubs, it will be found that the bearings are worn, and a new set will cure the trouble. To remove the hub, it is only necessary to take off the hub cap and unscrew the nut on the end of the stub axle. The hub and bearing assembly can then be withdrawn.

The lubrication of the hubs should be inspected at regular intervals, but they should not be over-lubricated, otherwise the excess grease will be thrown on to the brake drums.

Wheel Alignment

The alignment of the front wheels should be checked occasionally, particularly after any collision, or if the tyres are wearing badly. About $\frac{1}{8}$-in. toe-in should be given, measured at the centre-line of the wheel, the ends of the track rod being screwed right hand and left hand to facilitate this adjustment. After the adjustment has been made, be sure to tighten up the clamping bolt on both track-rod sockets, or damage to the adjusting thread will result if the sockets are allowed to run in a slack condition.

VACUUM SERVO

The vacuum servo is of the pedal type, controlled by a hinged pad on the pedal. A certain amount of care and attention is needed if the maximum of efficiency is to be obtained.

Testing Servo Operation

If the servo is suspected of being faulty, it can be tested by either of the following methods :

(*a*) Press brake pedal hard with engine stationary, and while still pressing start up engine. Immediately the effect of the servo will, or should, be felt, by a considerable reduction of the manual effort on the pedal. In this way the degree of assistance given by the servo can be judged.

(*b*) While still pressing on pedal switch off engine, when the loss of vacuum should produce a very noticeable reaction on the pedal.

If these two tests prove the servo to be working, but braking is still poor, the next thing to suspect is a leak in the pipe line, which may be traced by pouring oil from an oil-can over the pipe joints while the engine is running. If there is a leak the oil will be sucked in and slowly disappear.

In any case the leak has to be fairly considerable to have any material

effect on the power of the servo ; this may sound somewhat surprising, but it must be remembered that the engine is acting as a huge vacuum pump making vacuum far quicker than can be used by the servo.

Dismantling and Cleaning Servo

To remove the servo from the chassis, first disconnect the pedal rod from brake pedal, and the rear-brake rod from its connection to cross-shaft. Remove suction and oil pipes, taking care not to lose the special washers used for making the joints. Unbolt and remove servo from chassis, taking note if any packing or washers have been used in the fitting. If so, these should be carefully noted before refixing, otherwise, if any are misplaced, the servo casing may be strained or distorted when again bolted up to the chassis.

When dismantling, first of all remove the top cover and the cylinder end cover. Then, after disconnecting the lever axle, operating rod, and levers, the piston, complete with spring, chain, and lever mechanism, can be withdrawn through the cylinder bore.

Examine the cylinder, piston, and all joints for wear, and thoroughly clean with paraffin ; the piston leather should be carefully examined, and, if not perfectly soft and pliable, should be renewed. Under this leather is a hard-brass expanding ring, and this too should be inspected and, if necessary, slightly re-expanded so as to ensure its pressing the cup leather to make even contact on the walls of the cylinder. A fairly large working clearance is purposely allowed, but this cup leather must, of course, make good contact all round the bore to prevent leak.

The whole of the lever assembly should be carefully examined, and if any undue wear has taken place in any of the joints these should be rebushed or renewed.

When reassembling the servo all screws and nuts should be tightened up evenly, each a little at a time, particularly those on the cylinder end cover.

Great care must be taken to see that the servo is not strained when rebolted to the chassis.

Before coupling up the servo to brake pedal and brake cross-shaft, see that both of these work quite freely, and are well lubricated. A tight brake pedal will cause sluggish release of the servo, besides absorbing braking effort.

The rod coupling the servo to brake pedal should now be fixed, and great care taken to see that the levers in the servo are back in their rear-most position and the pedal in its fully " off " position. This is of the utmost importance, for the total travel of the servo must always coincide with the total travel of the brake pedal. This point should be very carefully checked before the brake rod from servo to brake cross-shaft is attached.

The length of the rod between the servo and brake pedal is of extreme

importance, and once determined should never require alteration, and on no account should any adjustment be made to the original setting. All adjustments must be made behind the servo.

Lubrication is provided by means of an oil-cup. This ensures that the servo gets the required lubrication if the oil-cup is filled with medium gear oil about every five hundred miles.

It is important that the rubber or leather gaiters on the servo are kept intact and well fitting. If allowed to become detached, or loose fitting, dirt and water are likely to get inside the mechanism and set up undue wear, and affect its efficiency.

STEERING GEAR

The steering gear is of the cam-and-lever type, giving the vehicle a turning circle of approximately 52 ft.

Adjustment for End Play

The adjustment for end play of the hardened steel cam is affected by a series of shims located between the end cap and the face of the steering box. Remove one or more of these shims, as required, until end play disappears, care being taken to see that when the end cap is securely rebolted, the thrust-bearings are still free to rotate. Care should be taken to see that the joint between the end cap and the box is properly remade if oil leakage is to be avoided. The gear should be filled up with oil to replace any loss during adjustment.

Adjustment for Play between follower and track

Adjustment for play between the follower and track is effected by renewal of the hemispheres, those on one or both sides of the follower being changed according to the degree of adjustment required. Remove the cover plate, and drain off sufficient oil to expose the cam and its track.

Withdraw the follower from its bronze bearing in the rocker shaft.

Replace one pair of hemispheres from one side of the follower by a new set, and insert the follower unit into the cam track in its mid-position, i.e. approximately midway between the two ends of the cam. This, for the moment, should be done independently of the rocker shaft, which should be moved over to one side to leave the centre portion of the cam track exposed.

Should further adjustment be required, the remaining set of hemispheres should be replaced in like manner.

Correctly adjusted, the follower unit should be a free sliding fit in the centre portion of the track, to ensure a free passage of oil between the surfaces, but only a minimum of side play should be permitted. Too close a fit will result in a stiff steering. This point determined, it now remains only to replace the follower unit through the rocker shaft and

into the track. This is most easily done with the rocker shaft over in the extreme lock position, as the track is purposely made slightly wider at these points. A little care should be exercised here, and the hemispheres may with advantage be slightly tilted in their seatings to give a lead-in effect when entering the track. A slight to-and-fro movement of the steering wheel in conjunction with a light pressure on the back of the follower facilitates this assembly.

When inserting a new set of hemispheres, see that they are quite clean and free from grit before inserting into the follower. A smear of thick grease in the seatings will check any tendency for them to fall out.

The cover plate and its shims should next be replaced, taking care to remake the oil joint properly, and the gear filled up with fresh oil.

The shims between the cover plate and the box should not be removed. They are intended for initial assembly only. A certain amount of end play is called for, and is desirable in the rocker shaft, and no attempt should be made to take this up by removing these shims.

Should the thrust-bearings be, for any reason, taken off the shaft, care should be taken to replace them the right way round. The right way round is when the word " thrust " stamped on one side of the inner race of the bearing is up against the end of the cam.

Refitting Drop-arm to Rocker Shaft

Should it be necessary to remove the drop-arm from the rocker shaft at any time, before doing this both these items should be marked, so that they can be fitted together again afterwards in the same relative positions.

In case this marking has been omitted or in case the marking has become obliterated, the following is the correct method of fixing this, and special attention should be given to this matter. Should this operation not be carried out properly, almost certainly the available lock will be limited in one direction or the other, and damage may result to the internal mechanism of the gear.

The steering column complete with steering box, but without the drop-arm attached, should first be fitted in place in the vehicle, taking care to tighten up all fixings holding the unit to the chassis, including that on the dashboard, the steering wheel being placed on its final position. Next, the lower end of the drop-arm carrying the ball pin should be fixed correctly to the drag-link, but the top end should not yet be connected to the rocker shaft of the steering box.

Now jack up the front wheels and place them approximately in the straight-ahead position.

If, now, the steering wheel is rotated gently, you will find that its movement is limited by internal stops in the steering box at each end of the travel of the internal mechanism of the gear. The number of turns of the steering wheel required to bring the gear from one end of its travel to the other should be counted. Then, commencing from one of these stops,

take the wheel back half the complete number of turns available, which will bring the steering mechanism into its central position.

Now, with the gear mechanism in this, its central position, as explained above, the front wheels set pointing slightly as though the vehicle were turning a right-hand corner, fit the serrated cone in the top of the drop-arm on to the rocker shaft. The reason the front wheels are set in this position is because in the ordinary fore-and-aft system of steering, the steering wheel has always to be moved through a greater angle when going from straight ahead to full right lock than when going from straight ahead to full left lock.

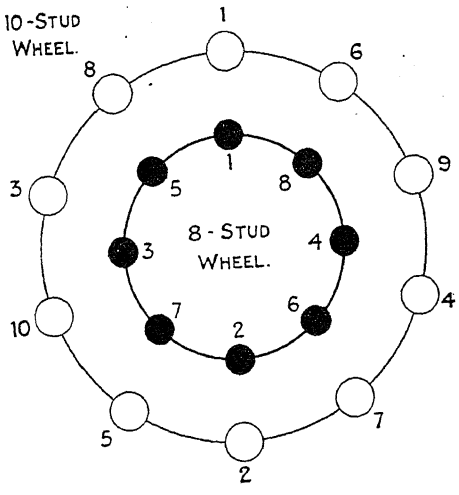


Fig. 4.—FITTING DISC WHEELS

Before tightening up, the following check should always be carried out.

The front wheels still being jacked up, with the steering wheel pull the steering right over to lock, either right or left. With the steering wheel and front wheels in this position, drop the drag-link off the drop-arm, and see whether you can move the steering wheel any farther in this same direction. If you can, everything is in order, and the same procedure should then be followed on the other lock.

Adjusting Front-axle Stops

Should further movement of the steering wheel be unobtainable, it means the front-axle stops are not operating, and some adjustment must be made, as follows :

If there is movement of the steering wheel available on one lock, but not on the other, the drop-arm should be put on the next serration on the rocker shaft, which may put matters right. If no serration will give free movement of the steering wheel at both locks, then the front-axle stops must be looked to, and altered, so that there is. The amount of free movement available after dropping the drag-link of the drop-arm should be the same at both locks, and this condition is what should be aimed at.

It will be appreciated that the movement of the rocker shaft and drop-arm is restricted by the internal stops fitted in the steering box, and it is therefore necessary to fix the drop-arm and connect the same up to the front wheels on the one hand, and to the steering-box mechanism on the other hand, so that the necessary movement of the front wheels from lock to lock is obtained at the same time as the follower is travelling from end

to end of the cam track, but not far enough in either direction to hit the internal stops in the steering box.

A large-size oil plug is provided at the top of the steering-box casting, and this box should be kept full of a medium gear oil.

Once the gear is full of oil, however, no attention should be necessary except periodically, say once in three months, to make up the full quantity of oil through this filler.

The design of the gear is such that the oil thus applied reaches every part of the gear.

A drop or two of castor oil now and again on the rubber and carbon bush at the top end of the steering-wheel spindle may be given, if necessary. Grease must not be used.

WHEELS AND TYRES

Disc wheels, having counterbored bolt holes, are carried solely on the plain cone or spherical faces of the studs and nuts.

They are not supported by the studs proper or by the spigot on the hub. The diameter of the bore of the wheel is slightly larger than that of the spigot, and there is always ample clearance for the studs in the stud holes.

Replacing Wheel

When replacing a wheel, screw up all the nuts until they just begin to grip, and then tighten them a little at a time in the order shown in Fig. 4 until fully home. This should be performed while the wheel is jacked up clear of the ground. The object is to enable the wheels gradually to seat themselves evenly on the faces of the studs and nuts ; the seating portion of the nut will then take up its correct position in the wheel.

It is specially important to observe this procedure when mounting twin wheels. It is extremely bad practice to screw one nut fully tight before moving to the others. When the vehicle is first put into service, or when a new wheel has been fitted, the wheel nuts are liable to work loose, so these should be tightened up daily to commence with, gradually extending the operation to a weekly period. After the wheels and nuts have " bedded down," a fortnightly inspection should be sufficient.

See that no rust tends to form on the studs or nuts if the wheels have not to be changed for a long period.

If there is a likelihood of this, due to exposure to mud or moisture, it is advisable to remove one nut at a time completely from its stud, smear the threads with gear oil or grease and replace it, or alternatively jack up each wheel, completely remove it, and attend to all studs and nuts.

Care of Tyres

Careful and regular attention must be given to the tyres if maximum service is to be obtained from them and maintenance costs are to be kept low.

Inflate the tyre to its correct pressure and check the pressure frequently with a pressure gauge and make up any loss ; running with slack tyres is injurious to the tyres themselves. Avoid fierce braking, if possible, as this increases tyre wear considerably.

If either of the rear wheels has to be changed, the spare should be as nearly as possible the same diameter as the tyre on the other side of the vehicle. If one is of larger diameter than the other, as in the case of a very worn tread compared with a new tread, the differential gear in the axle will be called upon to do more work than is intended. This, however, may be unavoidable at times, but the wheel should be changed at the first opportunity.

If twin-tyre equipment is fitted, and a new or different make of tyre is fitted to one wheel of a pair, it may be called on to carry an undue proportion of the load. This should be checked when fitted and is best done on a flat, smooth section of ground. Tyres should be matched as much as possible ; a slightly larger tyre of a pair should preferably be fitted to the outside, to be accommodated by road camber.

Road Springs

Long semi-elliptic springs are secured to the axles by our patent spring-fixing device, which allows freedom of action of the springs, and at the same time relieves the holding-down bolts of heavy stresses. It is however, as well to examine the bolts from time to time, particularly during the early life of the vehicle, to see that they do not work slack, as the springs also transmit the driving and braking thrust from the axles to the frame. Inspect the shackle bolts at the same time, and tighten if necessary.

As a general rule, in the case of spring breakage, only one leaf will be found to be broken, and the remaining leaves can be utilised to build up a new spring when a replacement leaf is obtained ; but it must be remembered that the severe strain which broke the one leaf must have been sustained by the other leaves, and they should be examined carefully for some time afterwards in view of other possible breakages.

When overhauling the vehicle, the springs should be removed so that the bushes and pins may be examined and the leaves dismantled and washed with paraffin, but before being reassembled they should be well greased all over with a mixture of graphite and grease.

Fuel System

The fuel tank is mounted on the side of the chassis frame, where it is easily accessible, the fuel feed being affected by an Autovac fitted to the dash. On the bottom of the tank a sump with drain plug enables the tank to be drained and flushed out. A glass-type fuel filter is fixed on the frame just in front of the tank, and periodically the bowl of the

filter should be taken off, and any foreign matter which has collected be washed out.

The filter consists of a series of corrugated plates mounted on a centre tube and held together by a knurled nut at the bottom of the centre tube. The corrugations are sufficiently small to allow only petrol to pass between these thin plates, so that foreign matter is trapped at the outside edges of the plates. The vibration of the vehicle as it travels should shake off this collection from the plates on to the bottom of the bowl, but it is also advisable to occasionally remove the bowl, slacken the bottom knurled nut, and spin the thin plates round to cast off any collected dirt. This is best done with the fingers, not with a cloth, which may leave fluff on the edges of the plates. Then tighten the knurled nut up with the fingers and thumb only. Too tight a nut tends to crush the corrugations out of the plates and stop even petrol from passing between them. The nut is captive on the centre tube, so that even if not tight enough the worst that can possibly happen is for it to work slack and allow dirt to pass between the loosened plates; they cannot come off. The fuel tap is underneath the Autovac in the feed pipe from the Autovac.

The Autovac requires little attention beyond draining out any sediment through the cock in the bottom about once a week, and cleaning the filter in the fuel-pipe connection at the top every month. See that the screws holding the top cover are tight, to ensure an air-tight joint.

The fuel tank has a capacity of 15 gallons.

Grease Specification

The grease used on the vehicle must be a smooth, well-manufactured product, made from a high-grade calcium soap and a highly refined, well-filtered, mineral oil of medium viscosity. It must conform to the following tests:

Consistency	Soft.
Ash	2·30 per cent. max. (as Ca°).
Moisture	1·00 per cent. max.
Resistance to water	It must not readily emulsify with water.
Melting-point	Not below 195° F. (*Ubbelohde*).

and be free from corrosive matter, grit, or fillers of any kind.

MOTOR REPAIR AND OVERHAULING

VOLUME III

BODY, CHASSIS, AND FRAME REPAIRS

Contributors to Volume III

H. W. ALLISON
R. A. BISHOP
A. A. BLAKER, M.I.A.E., A.M.I.M.E.
F. C. BROWN
G. T. CLARKE, F.I.M.T.
H. J. CURTIS
F. G. HAWKINS
A. F. HOULBERG
F. J. HUGHES, M.S.A.E., A.M.INST.T.
W. T. MEAD, M.I.M.T.
DOUGLAS PERCIVAL
J. W. SANDERMAN, A.M.I.A.E.
B. M. SMITH
S. E. SMITH
A. SQUILLARIO
K. SYLVESTER
C. W. G. TAYLOR
B. TURNBULL
D. H. WARREN

GEORGE NEWNES LIMITED
TOWER HOUSE, SOUTHAMPTON STREET, STRAND
LONDON, W.C.2

THE I. T. S. LIBRARY SERVICE
BANGALORE.

A Classified Key and Index to the subject-matter contained in this Volume will be found at the end of Volume IV.

PRINTED IN GREAT BRITAIN BY HAZELL, WATSON & VINEY, LTD., LONDON AND AYLESBURY

CONTENTS OF VOLUME III

PAGE

THE LUVAX HYDRAULIC SHOCK-ABSORBER 1
By Douglas Percival.

REMOVING DENTS FROM WINGS AND PANELS BY HOT-METAL SHRINKAGE 26

SPECIAL POINTS TO BE WATCHED WHEN REPAIRING STANDARD CARS . 39
By B. Turnbull.

SERVICING LANCHESTER CARS 49
Rear Axles, Braking System, Front Suspension, and Steering Gear.
By A. Squillario.

SERVICING VAUXHALL 10-H.P. AND 25-H.P. INDEPENDENT SUSPENSION SYSTEMS 62
By K. Sylvester.

REPAIR AND OVERHAUL OF FORD CARS 71
Rear Axles, Front Axles, Brakes, Steering, and Chassis.
By J. W. Sanderman, A.M.I.A.E.

SERVICING PACKARD SIX, EIGHT, AND SUPER EIGHT, 1937–9 . . 78

REPAIR AND MAINTENANCE OF TILLING-STEVENS CHASSIS . . . 84
Passenger (Type HA39A7) and Goods (Type HA39C4) Models.
By F. J. Hughes, M.S.A.E., A.M.Inst.T.

REPAIR NOTES ON S.S. JAGUAR CARS 93
$1\frac{1}{2}$-, $2\frac{1}{2}$-, $3\frac{1}{2}$-litre.
By D. H. Warren.

HUMBER INDEPENDENT FRONT-WHEEL SUSPENSION 97

SPECIAL POINTS TO BE WATCHED WHEN REPAIRING ALVIS CARS . . 111
By F. C. Brown.

SERVICING CHEVROLET CARS 126
Front-wheel Suspension and Brakes.
By N. A. Moore.

SPECIAL POINTS TO BE WATCHED WHEN REPAIRING GUY COMMERCIAL VEHICLES 143
By R. A. Bishop.

SERVICING COMMER VEHICLES 153
By B. M. Smith.

REPAIR NOTES ON VAUXHALL CARS 169

CELLULOSE REFINISHING FOR THE MOTOR TRADE 185
By H. J. Curtis.

LUVAX BIJUR CHASSIS LUBRICATION 201
By Douglas Percival.

SERVICE AND REPAIR NOTES ON GILFORD "HERA" 32/29 PASSENGER VEHICLES 219
By S. E. Smith.

PAGE

THE REPAIR AND MAINTENANCE OF ALL-STEEL BODIES . . 228
By A. F. Houlberg.

OVERHAUL OF 7-H.P. AND 10-H.P. AUSTIN REAR AXLES . . 277
By W. T. Mead, M.I.M.T.

EXAMINING A CAR FOR ACCIDENTAL DAMAGE AND FRAME REPAIRS . 289
By A. A. Blaker, M.I.A.E., A.M.I.M.E.

HOW TO LOCATE AND REMEDY CAR NOISES 319
By C. W. G. Taylor.

DENNIS 35-, 40-, 50-, AND 60-CWT. GOODS-CARRYING VEHICLE . . 325

HILLMAN MINX 341

REPAIR NOTES ON THE FIAT MODEL-500 CAR 353

LEYLAND VEHICLES 369

THE MORGAN 4/4 CAR 398

THE SCAMMELL MECHANICAL HORSE 403

REMOVING BODIES FOR FRAME REPAIRS 414

THE MORRIS EIGHT CHASSIS AND BODY (SERIES E) 422

ROVER REAR AXLES 432
By F. G. Hawkins.

THE TRIUMPH CHASSIS AND BODY 440
By H. W. Allison.

THE A.E.C. CHASSIS 449

ROAD SPRINGS AND SPRING BUSHES 467
By George T. Clarke, F.I.M.T.

VEHICLE BRAKE TESTING 487

THE BEDFORD CHASSIS 495

ADAPTING EXISTING BODYWORK FOR EMERGENCY USE . . . 511
By H. J. Butler.

ANDRE HYDRO-TELECONTROL SHOCK-ABSORBER SYSTEM . . . 528
By George T. Clarke.

THE MORRIS TEN CHASSIS (SERIES M) 538

RADIATOR REPAIRS 545

STRAIGHTENING, CHECKING, AND ALIGNING FRONT AXLES . . . 557

THE VAUXHALL FOURTEEN (MODEL "J") 567
With further Notes on the Ten and Twelve.

THE DAIMLER STRAIGHT EIGHT ($3\frac{1}{2}$-LITRE) 576
By A. Squillario.

THE THORNYCROFT STURDY CHASSIS 580
Chassis Type ZE 5-ton (Forward Control). YE 5-ton (Normal Control).

THE LUVAX HYDRAULIC SHOCK-ABSORBER

By DOUGLAS PERCIVAL

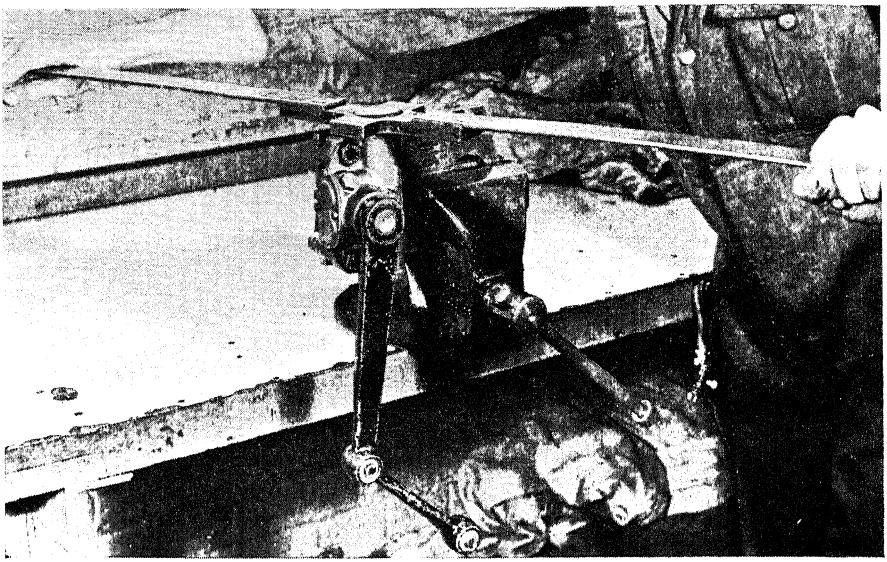


Fig. 1.—METHOD OF HOLDING THE SHOCK-ABSORBER IN A VICE FOR TIGHTENING END CAPS

ON present-day cars the hydraulic shock-absorbers form a very important part of the suspension system. Before dealing with their construction and maintenance, we will consider their function, as it is most necessary that this is clearly understood.

Why Shock-absorbers are Fitted

Shock-absorbers are fitted in an endeavour to provide a means of absorbing and dissipating the forces produced by the wheels travelling over irregular surfaces, which tend to impart vertical movement to the body. The springs, which form resilient members between the wheels and body, are intended to deflect or compress and thus absorb the "shocks" or disturbing forces. The primary function of the shock-absorbers is to dissipate these forces when thrown off by the springs in the form of "rebound."

It will, therefore, be seen that the duty performed by the shock-absorbers is not that which is implied by their name. This is responsible for causing a great deal of misunderstanding. A more descriptive name would be "spring dampers" or "oscillation retarders."

Let us analyse the motion of a car travelling over a rough road under the following conditions:

(1) Without springs or shock-absorbers.
(2) With springs but without shock-absorbers.
(3) With springs and hydraulic shock-absorbers.

What happens when a Car is without Springs or Shock-absorbers

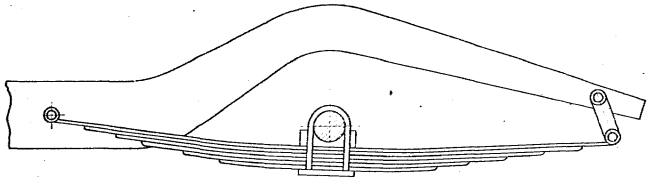
If a car is without springs, the shock occasioned by the wheels encountering bumps and depressions in the road would be transmitted direct to the chassis frame and body. All these would be thrown upwards and downwards in one mass, and the vertical accelerations and decelerations would be of a high order, dependent upon the force of impact between wheels and road—the result being acute discomfort to the passengers.

Car with Springs but without Shock-absorbers

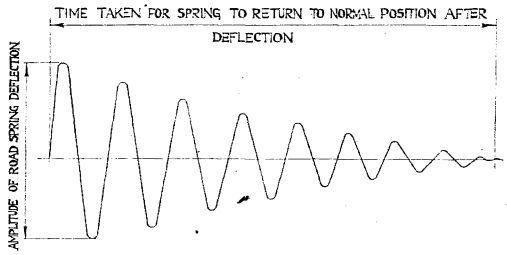
In order to obtain better results than in the above case, all cars are fitted with some form of spring interposed between the wheels and body—the conditions then being that the wheels can move vertically in relation to the body. When the wheels receive impact from road irregularities, they are forced towards the body, and the force or energy or shock, instead of being transmitted direct to the body is absorbed by the springs, which are compressed in the process. It should be noted that the energy is absorbed in the compressed springs, but not dissipated. In all springs the energy absorbed under these conditions must be thrown out again. The output of energy is responsible for what we term the "rebound," and this forces the wheels and body apart again. Subsequent to the rebound from the initial compression, the springs will continue to go up and down a number of times; these motions, or oscillations, we shall later refer to as "persistence." It will be appreciated that the conditions are better in this case than in the previous case, as the road shocks are absorbed by the springs, although there is the disadvantage of an uncontrolled rebound and subsequent oscillations which would produce what is commonly called "body bounce."

Conditions when a Car has both Springs and Shock-absorbers

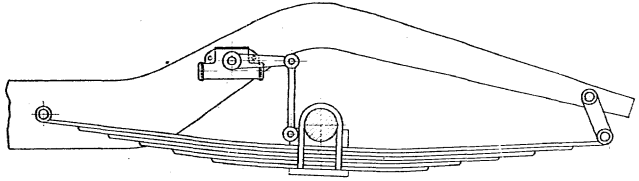
The final example is a car with road springs and hydraulic shock-absorbers. As in the previous case, the impact of the wheels against road irregularities produces a force which is absorbed by the springs, but in this case the resultant output of energy in the form of "rebound" and "persistence" is dissipated or damped by the hydraulic shock-absorber.



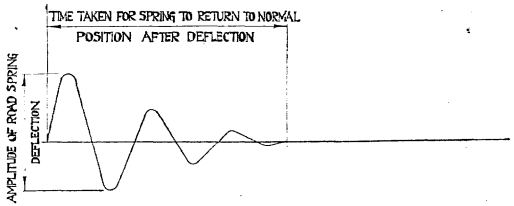
SPRING SUSPENSION SYSTEM ON REAR OF CHASSIS WITHOUT SHOCK ABSORBER



DIAGRAMMATIC OSCILLATION CURVE OF ROAD SPRING WITHOUT SHOCK ABSORBER



SPRING SUSPENSION SYSTEM ON REAR OF CHASSIS WITH SHOCK ABSORBER



DIAGRAMMATIC OSCILLATION CURVE OF ROAD SPRING WITH SHOCK ABSORBER

Fig. 2.—DIAGRAMMATIC OSCILLATION-CURVE OF A SPRING WITH AND WITHOUT SHOCK-ABSORBERS

In other words, the surplus energy in the spring is expended in forcing a volume of fluid through a small hole or valve in the shock-absorber, instead of by oscillating the body upwards and downwards. By this means a controlled "ride" is obtained, the springs flexing to absorb impacts and the hydraulic shock-absorber controlling the subsequent rebound.

The Ideal Road Spring and What has been attained in Practice

The above three examples touch only on the elements of the theory of suspension, and are intended to serve as an illustration only.

In actual practice there are many other considerations involved; for instance, the pneumatic tyres form a cushion between the wheels and road, and therefore play a part in the suspension system. Also, although the road springs are intended to absorb the shocks, in practice they only partly succeed, as no form of road spring has yet been found capable of absorbing *all* road irregularities without imparting some vertical movement to the body.

The perfect spring would deflect instantaneously the amount necessary to enable the wheels to follow the road contour, without disturbing the body, but this ideal has not yet been attained.

The Damping Effect of Shock-absorbers

Yet again, it is not found desirable to damp or retard the springs by the shock-absorbers to such an extent that they return from the compressed position to normal in one movement without subsequent oscillations. If this were done the rate of deceleration would be too high and would produce the effect of a harsh ride. The object at which to aim is to bring the springs to rest *smoothly* in the minimum time. This is illustrated in Fig. 2, which shows a diagrammatic oscillation curve of a spring with and without shock-absorbers. The amount of damping necessary to achieve the best results requires very careful consideration. It is not the same for a given size of car, that is to say, one make of 10-h.p. car may require quite a different type and amount of damping to a similar-h.p. car of a different design. One may require double-acting shock-absorbers and the other single, one high-resistance and the other low. This is because the damping required is dependent upon the characteristics of the road springs, weight distribution, and other factors, each of which may vary widely.

Importance of fitting the Correct Shock-absorber

The subject is an extremely complicated one, and, therefore, before a car manufacturer commences production of a new model there is usually a large amount of intensive research and experimental work carried out by the combined technical resources of the motor-car company and the shock-absorber manufacturers, in order to arrive at the most suitable

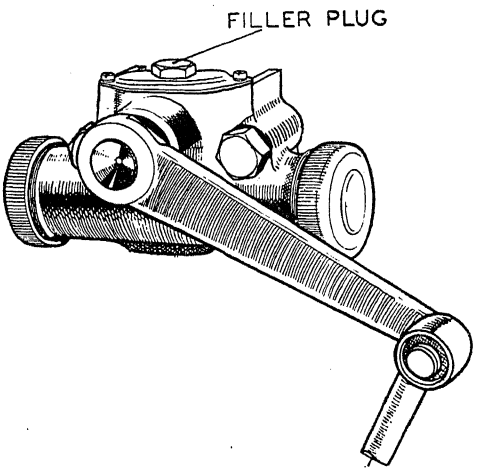


Fig. 2A.—LUVAX PISTON-TYPE SHOCK-ABSORBER

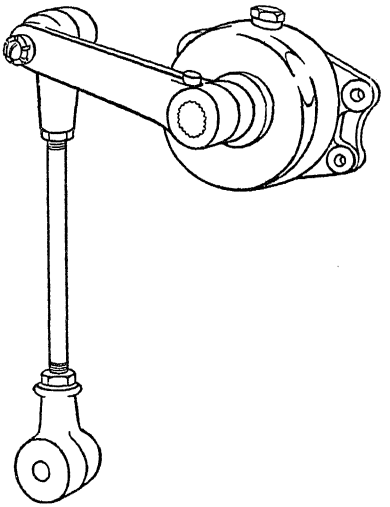


Fig. 2B.—LUVAX VANE-TYPE SHOCK-ABSORBER

shock-absorber characteristics for that particular model. It is, then, most important that the manufacturers' adjustment is not varied unless special conditions are to be catered for; also, when removing a shock-absorber from a car for replacement, care should be taken that the new unit has the same characteristics as that originally fitted.

Hydraulic and Dry-friction Shock-absorbers Compared

At this stage it may be of interest to consider why the hydraulic shock-absorber has been so universally adopted, to the almost total exclusion of the dry-friction type. The principal reason is because fluid friction increases with speed; this means that when the axle moves fast due to a big impact with the road, the hydraulic shock-absorber resistance automatically builds up to its maximum. With slow-speed axle movement the resistance offered by the shock-absorber is proportionately less—thus an automatic control is obtained. With dry-friction type the automatic "build up" with speed is absent, as dry friction is irrespective of speed.

CONSTRUCTION OF LUVAX HYDRAULIC SHOCK-ABSORBERS

The Luvax shock-absorbers are made in several different sizes and types, but may be divided into two main groups, the piston types and the vane types. They are both hydraulic and their function is the same, but their design and method of operation differ widely one from the other.

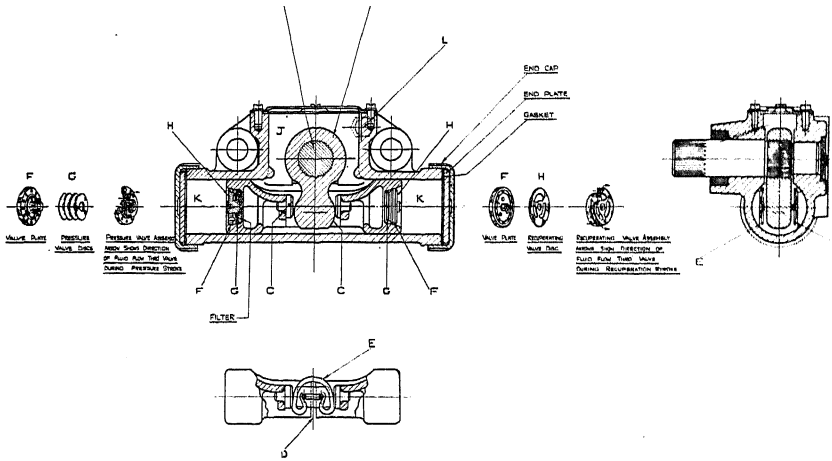


Fig. 3.—CONSTRUCTION OF THE DOUBLE-ACTING AND DIFFERENTIAL-ACTING PISTON TYPES

Piston Types of Shock-absorber

The piston type may be either double-acting, which gives equal resistance in both directions; differential-acting, which offers more resistance to the recoil of the road spring than the compression; or single-acting, which offers resistance to the recoil of the road spring only, being free in the other direction.

The double-acting and differential-acting types are of the same construction. The different effect is obtained by arranging the internal valves as required, this being done during their manufacture. They are of the horizontal-cylinder twin-piston type, and are normally mounted on the chassis frame and connected by means of a lever arm and link to the axle. On some cars it has been found more convenient to mount them on the axle and to connect by the arm and link to the frame, but there are only a few instances of this being done. Fig. 6 shows a typical layout with the shock-absorber mounted on the frame.

The single-acting type has only one piston, and is usually mounted with the cylinder vertical. It is normally mounted on the frame, but may be mounted on the axle if necessary. The axle movement is transmitted by a similar arm and link to that used with the double-acting type.

The Double-acting and Differential-acting Types

The construction of the double- and differential-acting types is illustrated in Fig. 3, and the description is as follows:

Mounted on the rocker shaft *A* on tightly fitting serrations, the rocker *B* converts the rotary motion of the shaft to the reciprocating motion of the pistons through the hardened surfaces *CC*. The pistons are co-axial, but separated by the division *D*; the springs *EE* flexibly join the two

pistons. Any wear on the faces *C C* is thus taken up automatically. It will be seen that the thrust from the rocker is taken direct on the piston, without passing it through the springs.

In the outer ends of the pistons a circular valve plate *F* is fitted. This carries on its inner seating the pressure valve *G*, which is arranged to open when the predetermined pressure is reached. On the outer seating of the plate *F*, a recuperator valve *H* permits the fluid to flow freely from the recuperator chamber *J* to the pressure chamber *K*. There is also a small orifice in the outer end of the piston which allows a small flow of fluid to pass from the high-pressure chambers to the recuperator chamber. This is referred to as the " bleed," and it controls the resistance at speeds lower than that which is required to open the pressure valve *G*.

The filler plug *L* is positioned to give the correct fluid-level. This is obtained by pouring in fluid until it overflows.

The operation on the car is as follows :

When the body and axle are forced towards each other (road springs compressing), motion is transmitted by the connecting link and lever arm to the rocker shaft, which rotates and causes lateral movement of the pistons, let us say, to the left. At the commencement of the stroke resistance is offered dependent on the pressure required to force the fluid in the left-hand pressure chamber, through the bleed in the piston, to the recuperator chamber. As the axle speed (and therefore piston speed) increases, the pressure or resistance builds up according to the hydraulic law, the limit being reached when the pressure valve *G* opens. During this stroke the recuperator valve *H* in the right-hand piston opens and allows free flow of fluid from the recuperator chamber to the pressure chamber, thus ensuring that it is kept completely full of fluid. Movement to the right follows the same cycle.

The " bleed " and the tension of the pressure valves *G* are accurately calibrated during manufacture, so as to be of the correct value for the car to which they are to be fitted. No further adjustment is required or provided for.

In the double-acting type, the bleed and pressure-valve values are the same in both pistons ; in the differential-acting type the bleed and/or pressure-valve values are lower on the side which takes the compression of the road spring than on the recoil side.

The lever arm is a force-fit on the shaft serrations, and the end of the shaft is " staked " in three places to retain the lever longitudinally. The connecting link is bushed with special torsion rubbers which form silent, oil-less, flexible bearings.

Single-acting Piston Type of Shock-absorber

Fig. 4 shows the construction of the single-acting type, which is described below :

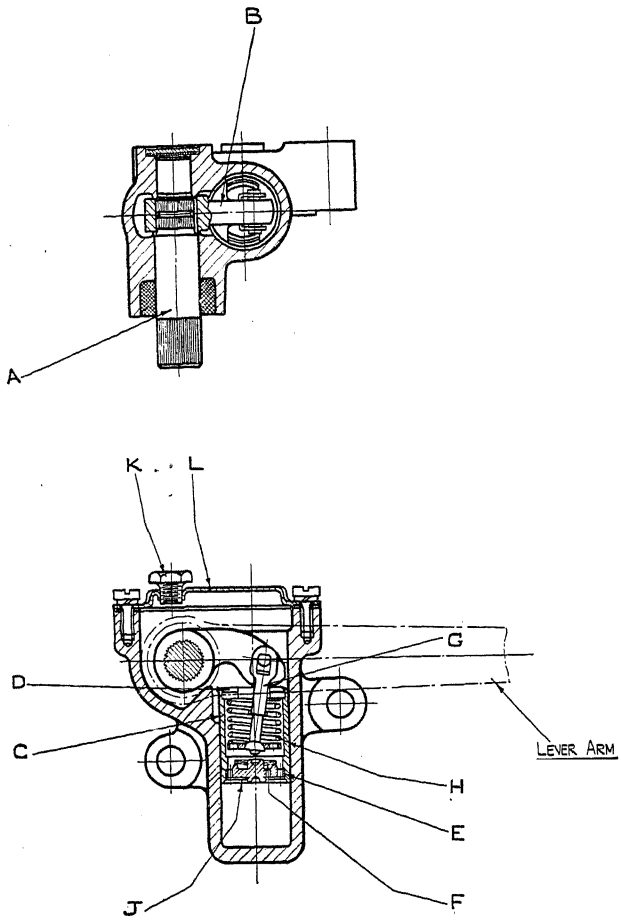


Fig. 4.—CONSTRUCTION OF THE SINGLE-ACTING PISTON TYPE

When the lever arm moves downwards, the rocker *B*, which is mounted on the shaft *A* on tightly fitting serrations, forces the piston *C* downwards by pressure on the hardened surface *D*. In the lower end of the piston a circular valve-plate *E* is fitted. This carries on its inner seating the pressure valve *F*, which is arranged to open when the predetermined pressure is reached. This permits fluid to pass from the under side of the piston, which is the pressure side, to the upper side, which is the low-pressure or recuperator-chamber side. There is also a small orifice in the end of the piston which permits a small flow of fluid to pass from the high- to the low-pressure side. This is referred to as the "bleed," and it controls the resistance at speeds lower than that which is required to open the pressure valve *F*. The piston is flexibly connected to the rocker arm by means of the coupling yoke *G* and the compression spring *H*. The pressure exerted by spring *H* holds the rocker in close engagement with the piston under all conditions, and automatically takes up any wear which may occur on the rocker or piston face. When the lever arm moves upwards the piston is drawn upwards in the cylinder by the rocker and coupling yoke. During this stroke fluid is permitted to pass freely from the upper side of the piston to the lower by the lightly loaded recuperator valve *J*. The pressure

chamber is thus kept solidly full of fluid in readiness for the next pressure stroke.

The filler plug *K* is positioned in the top cover *L*. The correct fluid-level is obtained by pouring in fluid until it overflows.

The operation on the car is as follows :

When the body and axle are forced towards each other (road springs compressing), motion is transmitted by the connecting link and lever arm to the rocker shaft, which rotates. The piston is drawn upwards in the cylinder, and as the fluid may pass freely through the recuperator valve *J* there is no resistance. The transfer of fluid through valve *J* ensures that the pressure chamber is always solidly full of fluid. When the body and axle move away from each other (road spring extending or rebounding), the piston is forced downwards in the cylinder. At the commencement of this stroke resistance is offered dependent on the pressure required to force the fluid below the piston through the " bleed " to the low-pressure side. As the axle speed increases, the pressure or resistance builds up, the limit being reached when the pressure valve *F* opens. The " bleed " and tension of the pressure valve *F* are accurately calibrated during manufacture so as to be of the correct value for the car to which they are to be fitted. No further adjustment is required or provided for.

Vane-type Shock-absorber

The Luvax vane-type shock-absorber is shown in Fig. 5. The construction and operation are simple, so that only the following brief description is necessary.

They may be either single-acting, differential-acting, or double-acting, the different effect being obtained by the arrangement of the internal valves. The principal components are the working chamber *A*, the reacting block *B*, the rotor *C*, the recuperator chamber *D*, and the bottom cover *E*. The shock-absorber is normally mounted on the frame, with the rotor shaft connected to the axle by a similar type of lever arm and link to that used with the piston type. The filler plug *F* is situated on the top of the recuperator chamber, and the correct fluid-level is $\frac{3}{4}$ in. from the top. The working chamber should always be completely full.

The operation of the double-acting type is as follows :

As the car spring compresses, the lever arm moves and rotates the rotor, let us say to the right. The rotor vane forces the fluid in front of it through the transfer hole *G* in the reacting block to the other side. The flow of fluid through the transfer hole *G* is partially obstructed by the adjusting screw *H*. Thus resistance is offered to the lever-arm movement, dependent upon the pressure required to force the fluid past the adjusting screw. The rebound of the car spring causes the rotor to rotate in the opposite direction, the vane of the rotor again forcing the fluid through the partially obstructed transfer hole *G*. The resistance

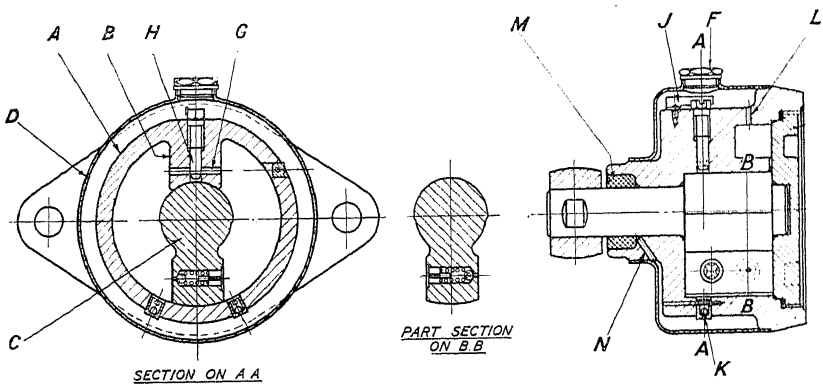


Fig. 5.—CONSTRUCTION OF THE VANE TYPE

offered is the same in both directions. It will be readily seen that screwing the adjusting screw upwards or downwards decreases or increases the resistance. The adjusting screw is screwed with a fine thread and has a tapered point, so that a very fine adjustment can be obtained. The locking spring *J* locks the adjusting screw every one-sixth turn.

To safeguard against any possible loss of fluid in the working chamber, a means of automatic recuperation is provided by the recuperator chamber *D*, which carries a large supply of reserve fluid, which is drawn through the recuperator valves *K* into the working chamber when required, the air being discharged through the air-release duct *L*. The gland *M* prevents any escape of fluid along the rotor shaft, and the duct *N* allows any excess to return to the recuperator chamber.

The differential- and single-acting types operate in the same manner as above, with the exception that a spring-loaded by-pass valve is incorporated in the reacting block to give an additional path for the fluid on the compression stroke of the car spring. This valve is arranged, during manufacture, to offer the required resistance for differential action or to permit a free flow for single action.

The construction of the by-pass valve varies in different models; it may be either a ball valve or a sleeve valve, but the principle of operation is the same. In some instances a spring-loaded valve is incorporated for both the compression and rebound strokes, to limit the resistance building up beyond a predetermined figure.

MAINTENANCE AND SERVICE REPAIRS

Maintenance of Piston Types

Occasionally a check should be made to ascertain if they require replenishing with fluid. This is done by checking the resistance, which, if uniform throughout the complete stroke of the lever arm, indicates that

the fluid-level is adequate. The resistance of each shock-absorber may be quickly checked by bouncing each corner of the car up and down and observing the movement. If there is any doubt that the springs are adequately controlled, a more positive check should be made by disconnecting the shock-absorber connecting links and moving the lever arms by hand. If the resistance in any one shock-absorber does not feel uniform, but appears to be erratic with free movement during part of the stroke, the shock-absorber should be removed from the car for topping up with fluid.

It is recommended that the units are removed from the car for topping up, as it is vitally important that no dirt or foreign matter enters. When a shock-absorber has been removed, it should be wiped clean before the filler plug is taken out. Fluid may then be poured in until it overflows from the plug hole. Whilst this is being done the lever arm should be worked up and down through its full stroke to expel air from the pressure chamber.

In all the piston-type units, it is most important that only Luvax Piston Type Thin Fluid is used. This is a special fluid, the properties of which have been carefully selected to comply with the conditions essential for the efficient working of the shock-absorber.

Service Repairs of Luvax Piston Types

If a repair becomes necessary owing to trouble developing, such as loss of resistance or fluid leakage, etc., it is advisable under normal circumstances, unless the required repair is of a very minor nature, to return the complete unit to the manufacturers for rectification or replacement. Special tools and plant are required for carrying out repairs efficiently and economically, and the installation in garages or service stations of the complete equipment would not be justified by the relatively small number of repairs handled. Instances may be met with, however, where obtaining a manufacturer's repair or replacement may involve a delay which would inconvenience the customer. To meet such circumstances we will describe a number of repairs which can be carried out satisfactorily in the garage with the aid of a few special service tools and spare parts, which may be obtained from the manufacturers.

Troubles and Remedies—Horizontal Double-piston Type

Here are some troubles which may possibly occur with the horizontal double-piston type, with instructions for carrying out a service repair should it be found necessary.

Fluid Leakage from High-pressure Joints

There are only two high-pressure joints, namely the two screwed-on end caps, one at either end of the cylinder. If leakage occurs at one of these it will probably be caused by the cap not being sufficiently tight.

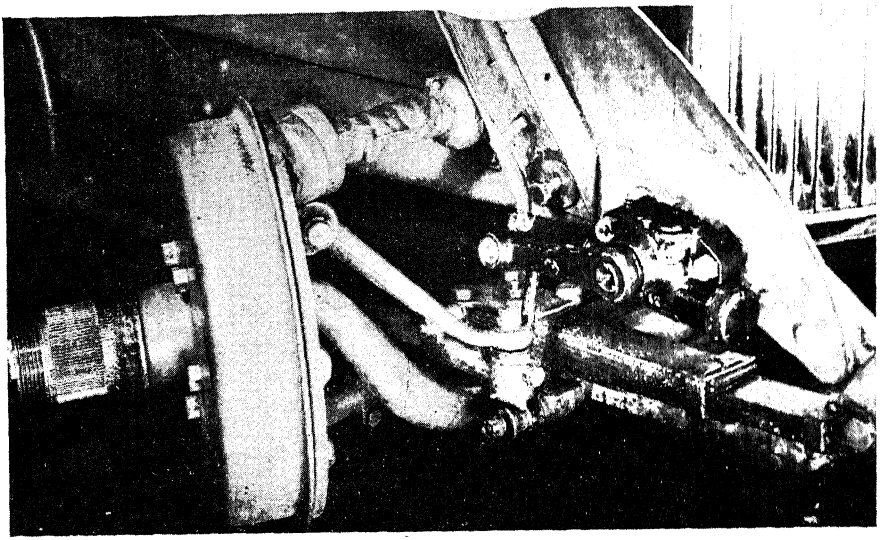


Fig. 6.—TYPICAL MOUNTING ON FRONT OF CAR OF A LUVAX HORIZONTAL PISTON-TYPE SHOCK-ABSORBER

They must be properly tightened up, and this should be done with the special spanner supplied by the makers. This is such that it gives a perfectly even grip around the cap and so avoids distortion. If the cap is distorted during tightening, a fluid-tight joint will not be made. In order to hold the shock-absorber firmly in the vice without damaging the casting, or distorting the cylinder, it should be bolted to a piece of flat steel plate approximately $\frac{1}{2}$ in. thick and the plate clamped in the vice as shown in Fig. 1. There are four sizes of Luvax piston-type shock-absorbers, and it is well worth while drilling a plate with four sets of holes so that it is suitable for any size.

Fluid Leakage from Shaft End Washer

Another possible leakage point is from the shaft end washer. This is a well-known type of sealing washer. It is a domed steel washer which, when assembled, is flattened out, thus forcing the outer edge into a groove in the casting. If leakage occurs, pressure applied to the centre of the washer will tighten the joint. This job may be readily accomplished in a vice by holding a short piece of round steel bar against the domed washer and clamping the end of the bar and the end of the shaft between the jaws of the vice, as shown in Fig. 7.

Leakage at Top Cover

A leakage at the top cover may usually be rectified by tightening the cover-retaining screws. If, however, this does not have the desired effect,

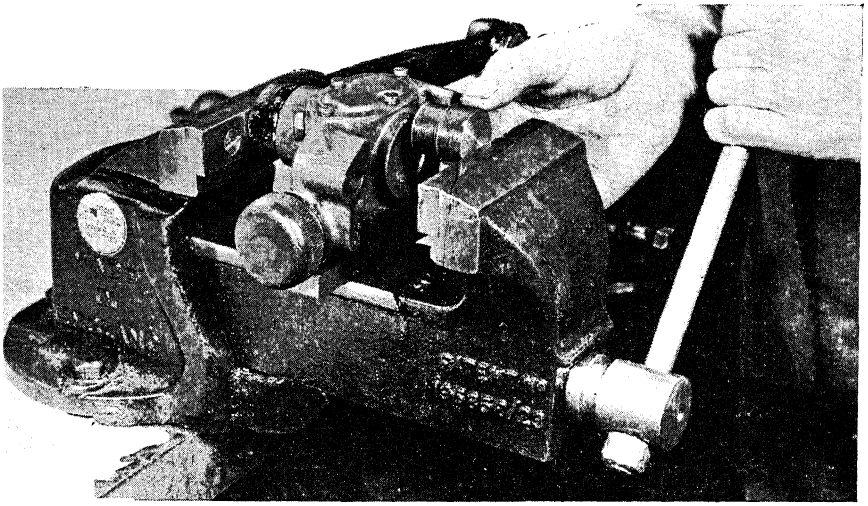


Fig. 7.—METHOD OF TIGHTENING THE SHAFT END WASHER IN A VICE

it may be that a new gasket is required or the cover has become distorted. Spares may be obtained from the makers. We would emphasise the importance of obtaining spare parts only from the makers of the shock-absorbers, in order to ensure interchangeability and reliability. A jointing compound such as Hermetite is used to assist in making the joint. Before fitting a new gasket or cover or refitting the old one, the original jointing compound should be carefully scraped away from both these parts and also from the top of the casting, care being taken to avoid any particles falling inside. We again make special mention of the vital importance of ensuring that no particles of dirt or foreign matter enter the shock-absorber. If small pieces of solid matter are trapped under the valves, it will prevent their closing properly and resistance will be lost. Care should also be used when assembling to prevent excess compound being used and squeezed into the shock-absorber. Tighten each retaining screw a little in turn so as to pull down the cover evenly and avoid distortion.

The Gland

The gland is of such a construction that it cannot leak, and it needs no attention throughout the entire life of the shock-absorber.

Remedying Loss of Resistance

If the resistance is found to be weak or erratic and cannot be restored by topping up with fluid and expelling the air by working the lever arm up and down, as described under "Maintenance," an examination of the unit should be carried out.

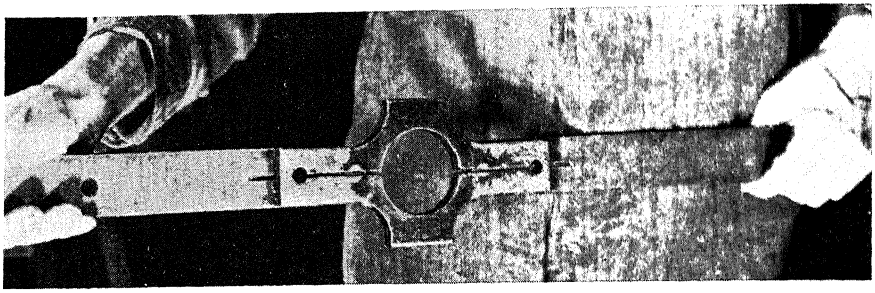


Fig. 8.—END-CAP SPANNER FOR PISTON TYPE

Loss of resistance in one or both directions may be caused in several ways; it may be due to fractured internal parts, such as the shaft or rocker arm or piston coupling linkage. In such cases the shock-absorber should be returned to the manufacturers for repair, as a complete dismantle is involved, but it is very seldom that any of these failures occur. A more likely cause of lost resistance is a faulty valve. This may be due to dirt or foreign matter under the valve discs preventing them from seating correctly, or to a mechanical failure of the valve parts. A faulty valve or valves in one piston only will affect the resistance in one direction only, i.e. when that piston is moving through its pressure stroke. If the valves in both pistons are faulty, then the resistance will be affected in both directions. This trouble may be rectified as follows:

Rectifying Faulty Valves

Mount the shock-absorber on the clamp plate and tighten up in a vice as shown in Fig. 1. If the resistance is affected in one direction only, mount the shock-absorber so that the affected piston is uppermost. If it is weak in both directions, each end must be treated in turn. Using the special end-cap spanner (Fig. 8), unscrew and remove the end-cap, end-plate, and gasket. Move the lever arm so that the piston is brought to the end of the cylinder. In most of these units the valve-plate (which carries the pressure and recuperator valves) is retained in the end of the piston by a spring clip. This enables the complete valve-plate, with valves, to be readily removed.

Units with Spring-retained Valve-plates

The following instructions appertain to units with spring-retained valve-plates. There is a small hole in the centre of the valve-plate, tapped with a 5BA thread into which a screw may be inserted. A straight pull on the screw by hand will withdraw the plate from the piston. Mention must be made here that the "bleed" hole in the piston is fitted with a small, accurately sized meter-pin, which controls the fluid

flow. This pin is a little less than $\frac{1}{16}$ in. diameter by approximately $\frac{1}{4}$ in. long. It is held in position by the valve-plate, consequently when the plate is withdrawn the meter-pin may fall out. It should therefore be removed and carefully kept on one side, so that it may be reinserted in the "bleed" hole before the valve-plate is reassembled in the piston. Always replace the meter-pin in the same piston from which it was removed. Having withdrawn the valve-plate from the piston, the recuperator valve should be carefully examined.

In some models the recuperator valve disc is riveted to the valve plate, in other types the disc is held against the plate by the plate-retaining spring. Dealing with the riveted type first, if a particle of solid matter is found trapped between the disc and the plate, it should be carefully removed by a feeler of approximately ·005 in. thick, inserted between the two. It should be noted that a minute particle under the disc will prevent its seating properly. Avoid raising the disc more than necessary or it may become distorted. If the disc is found to be broken or distorted, a new valve-plate complete with discs must be fitted. The type of recuperator disc which is held in position by the retaining spring may be removed from the plate and wiped with a clean rag to remove any particles which may be under it; the face of the valve-plate should also be wiped clean. If the disc is found to be damaged a new one should be fitted.

Trouble caused by the Pressure Valve

If the recuperator disc is found to be free from obstruction and in good condition the trouble is probably being caused by the pressure valve. The construction of this valve is such that a garage repair is not a practical proposition, and the remedy is to fit a new valve-plate complete with discs. This may be obtained from the manufacturers, but it is most important, when ordering, to quote the symbol number which is stamped on the outside of the shock-absorber, and also to state for which end of the unit it is required, i.e. for operation during compression or recoil of the road spring. As an alternative to quoting the symbol number of the shock-absorber, the details of the car from which it was removed may be given thus: "One valve-plate assembly complete (road spring recoil side) for shock-absorber removed from 1939 Morris 10-h.p. Offside Front." When fitting the new valve-plate to the piston, great care must be taken to avoid distorting the recuperator-valve disc. An ordinary flat washer placed over the disc whilst the plate is being pressed home will give protection. Discretion must be used as to whether it is necessary completely to flush out the shock-absorber before reassembling the end cap. If the fluid appears perfectly free from solid matter, the valve-plate may be reassembled to the piston and the gasket, end-plate and end-cap refitted. No jointing compound should be used when fitting the end-cap gasket.

Reassembly of the Unit

It will be seen that serrations are formed in both the end of the cylinder and in the end-plate. A fluid-tight joint is made when the gasket is pinched between these serrations as the end-cap is tightened up. If it is found that there is a quantity of dirt or foreign matter in the fluid, it is obviously no good reassembling the end-cap until the unit has been thoroughly cleaned out. To do this successfully the top cover, both end-caps, and the valve-plates should be removed ; then thoroughly flush out to remove all trace of dirt. For this purpose the manufacturers use trichlorethylene, but if this is not available paraffin may be used as a substitute. After flushing, an air blast should be used. In most models a wire gauze filter is fitted behind the valve-plate. The filter should be cleaned so that the fluid may pass through it freely. The unit may now be reassembled and filled with the correct fluid.

Dealing with Press-fit Valve-plates

We come now to the type of valve-plate which is not retained in the piston by a spring clip but is made a "press fit" in the piston. With this construction the fit of the plate has to be of sufficient tightness to retain it in position, and therefore it is more difficult to withdraw from the piston and to reassemble than the spring-retained type. In view of this it will probably be found most convenient to return this type of unit to the manufacturers for any attention necessitating the removal of the valve-plates. If, however, circumstances call for this job to be carried out as a service repair, great care must be taken in withdrawing the valve-plate ; the best method is as follows : There is a tapped hole (size No. 5BA) in the plate into which a withdrawal screw may be inserted, and a "pull" exerted by leverage against the end of the piston. It should be noted that the withdrawal load must not be taken against the end of the cylinder or damage will result. A short piece of thin tube, about $\frac{1}{16}$-in. wall thickness and the same diameter as the piston, should be placed against the piston end to take the load. Having withdrawn the plate, proceed as with the spring-retained type.

Dismantling and Reassembly of Lever Arm and Connecting Link

The lever arm and connecting link are robustly constructed, and the special rubber bearings have a long life, so that repairs to these parts are seldom necessary. We will, however, describe the procedure for dismantling and reassembling in case the necessity should arise for fitting a replacement. The lever arm is a "force fit" on the shaft serrations, and the end of the shaft is staked or riveted over in three places to retain it. This type of lever-arm fixing is very efficient, but occasionally a lever will work loose. In the majority of cases, when this occurs, the serrations of both the lever arm and the shaft become damaged.

Therefore a shock-absorber with a loose lever should be returned to the makers complete with the arm and link for repair.

The connecting-link bearings are assembled with special tools, the rubber being under high compression. In the event of its becoming necessary to fit a new connecting link, rubber bush, or connecting-link pin, the old rubber should first be pressed out, under a small press. To assemble one of these bearings, a set of three special tools is necessary, i.e. a guide funnel, a punch, and a tapered guide-pin. It is possible to do this job by hand, but it can be carried out much more conveniently under a small press. The first operation is to press the rubber bush into the boss of the lever. To do this the guide funnel is used. It has a tapered bore down which the rubber bush is pressed by the punch into the hole in the lever as shown in Fig. 9. The next operation is to assemble the connecting link or pin into the rubber. To do this the tapered guide-pin is attached to the connecting link or pin, which is then forced smartly downwards into position by the press, as shown in Fig. 9A. The parts, including the rubber, should be washed in paraffin before assembly to remove all traces of grease and dirt, and should be taken direct from the paraffin bath on to the assembly fixture.

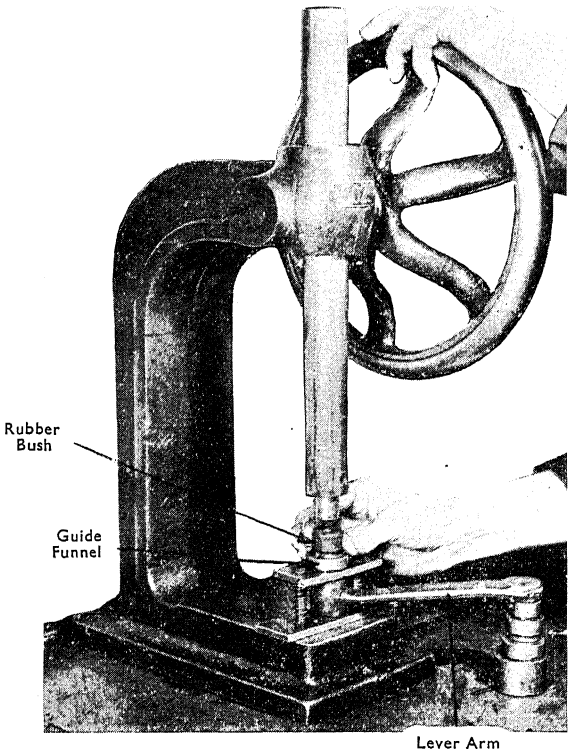


Fig. 9.—ASSEMBLING THE CONNECTING-LINK BEARINGS (1)

Dealing with Faults in Single-acting Piston Type

The methods of dealing with the faults which may arise in the single-acting piston type are similar to those already described for the horizontal double-piston type, with the following exceptions. When the top cover of the single-acting type is removed, the piston may be completely withdrawn from the cylinder if the coupling yoke is prised upwards sufficiently

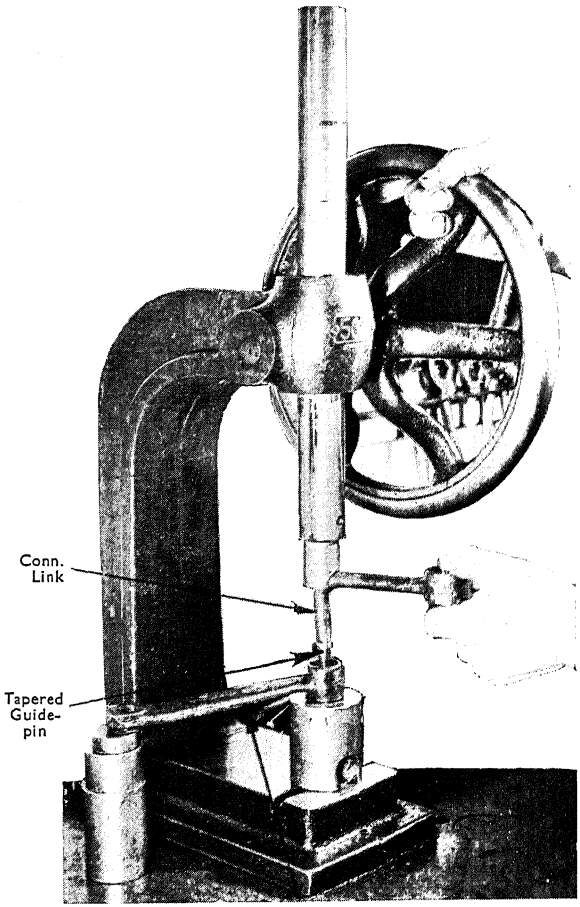


Fig. 9A.—ASSEMBLING THE CONNECTING-LINK BEARINGS (2)

to permit the transverse pin in the rocker arm being withdrawn. It will be seen there are two slots in this pin, into which the yoke locates. There are two small lugs on the side of the coupling yoke, under which a tool may be inserted to prise it upwards as shown in Fig. 10. Having disengaged the coupling yoke, the rocker arm may be swung backwards and the complete piston assembly withdrawn. As in the case of the horizontal double-piston type, the "bleed" hole with its meter-pin is situated near the valve end of the piston. On withdrawing the piston from the cylinder, this meter-pin should be carefully removed, to prevent its falling out and becoming lost. Make sure the same pin and piston are used when reassembling, as they have been graded with the cylinder bore to give the correct resistance. The lever arm and connecting link are of similar construction to those used with the horizontal double-piston type already described.

Maintenance of Vane Types

The maintenance work necessary with the vane type is, with the two following exceptions, the same as already described for the piston types.

Firstly, it is very important that only Luvax Vane Type Thick Fluid is used in the Luvax vane-type shock-absorbers. This fluid differs very

widely from the Piston Type Thin Fluid, and the two will not mix.

Secondly, in the vane types the correct fluid-level is obtained by filling to within approximately $\frac{3}{4}$ in. of the top of the outer casing. It is important that care be taken to avoid overfilling, otherwise leakage will occur when the fluid expands, as it heats up to working temperature, which is approx. 90° F. It is sometimes rather difficult to see the fluid-level inside the casing, but a convenient method to adopt is to fill to the top and then pour out about one tablespoonful. Move the lever arm by hand. If there is any free movement, the arm should be worked up and down. This will have the effect of drawing fluid from the recuperator chamber, through the recuperator valves, to the working chamber, and the free movement will be felt to become smaller and smaller until it disappears. While doing this, the lever should not be moved beyond the point where fluid resistance is felt; that is to say, only move it up and down to the extent of the free movement.

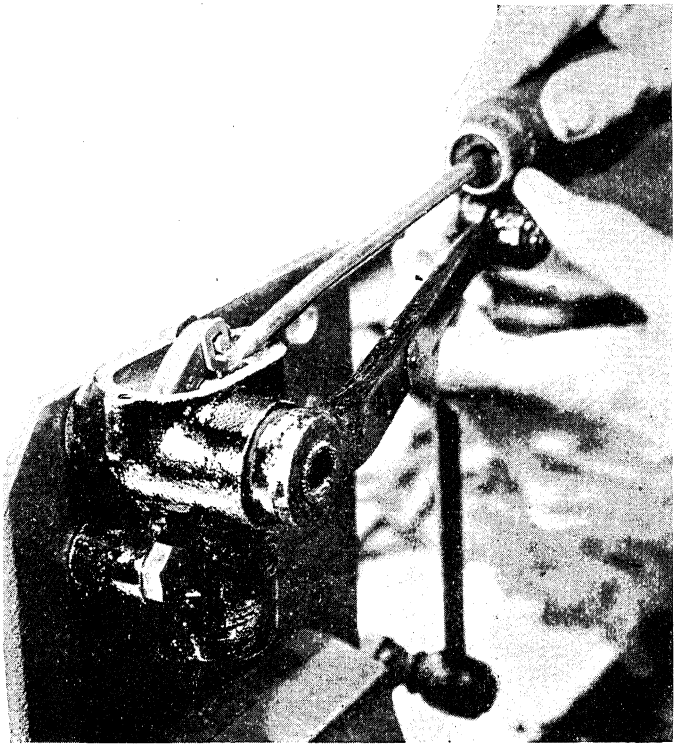


Fig. 10.—SHOWING HOW THE COUPLING YOKE IN THE SINGLE-PISTON TYPE MAY BE DISENGAGED

Service Repairs of Luvax Vane Types

Similar remarks apply to vane-type repairs as to those we have already made in connection with piston types, i.e. it is advisable under normal circumstances to return a faulty unit to the manufacturer for repair or replacement. Should, however, an instance be met with when there is no time available for this procedure, the following repairs may be carried

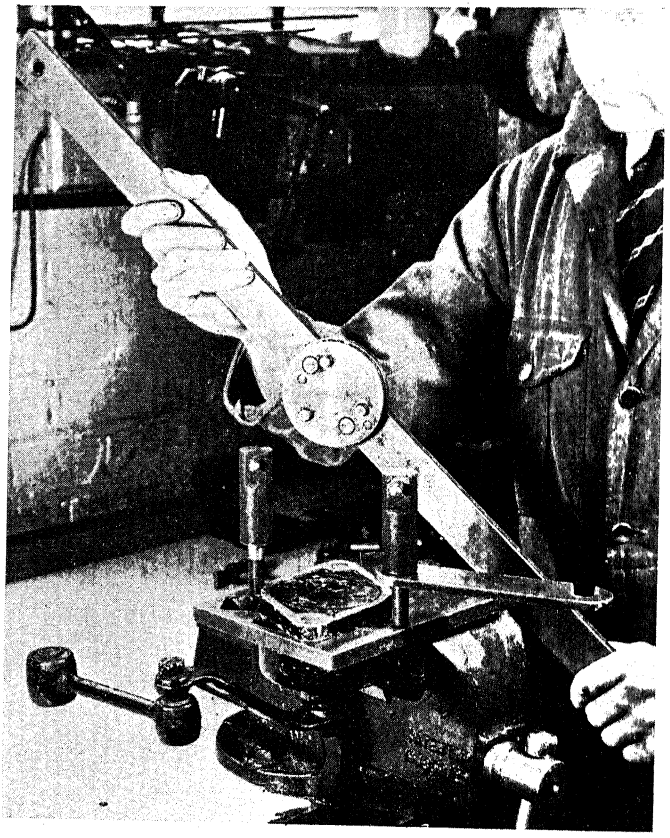


Fig. 11.—METHOD OF TIGHTENING THE BOTTOM COVERS IN VANE TYPE (1)

out in the garage with the aid of a few special service tools.

Fluid Leakage

The only high-pressure joint is at the point where the bottom cover screws into the working chamber. Leakage at this point may usually be remedied by tightening the bottom cover. This operation requires a special spanner on which are formed projections which locate in a recess in the bottom cover. In addition to this a simple fixture is needed, as shown in Fig. 11; it comprises a plate to carry the shock-absorber and a clamp bar to hold the spanner projections in engagement with the bottom cover. The fixture should be held firmly in a vice, as shown in Fig. 11A, and the bottom cover screwed down into the working chamber as tightly as possible. If tightening the bottom cover does not prevent the leakage, it may be that a new gasket is required. Spare gaskets, which are made of a special rubber, may be obtained from the makers. When fitting one of these, the bottom cover should be unscrewed from the working chamber and the old gasket removed. The new gasket should then be stretched into position over the spigot of the bottom cover, care being taken to see that it is quite flat. Smear the gasket with shock-absorber fluid before screwing the bottom cover into the working chamber; this prevents the gasket from buckling when tightening down.

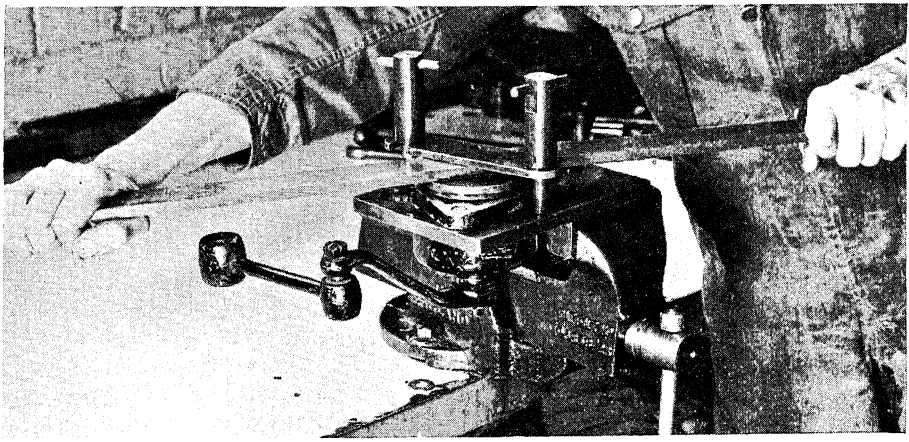


Fig. 11A.—METHOD OF TIGHTENING THE BOTTOM COVERS IN VANE TYPE (2)

Should leakage occur at the joints between the recuperator chamber and the working chamber, the unit should be returned to the manufacturers, as the repair involves the fitting of a new recuperator chamber, which requires special plant.

On all Luvax vane-type models manufactured since approximately 1933, the gland is of a similar construction to that used in the piston type already described, and requires no attention throughout the life of a shock-absorber.

Loss of Resistance

If resistance has been lost, and cannot be restored by "topping up" and expelling the air as described under "Maintenance," it may be due to the internal valves having become stuck up. This may be caused by incorrect fluid having been used which has congealed, or dirt having been allowed to enter through the filler-plug hole. The remedy is to thoroughly flush out the shock-absorber with paraffin. If a bottom-cover spanner and fixture are available, the bottom cover should be removed and the working chamber flushed out. The recuperator chamber should also be flushed through the filler-plug hole. If a bottom-cover spanner is not available, the working chamber may be flushed out through the adjusting-screw hole. To do this, remove the filler plug and adjusting screw, but first of all note the number of turns it is opened from the fully shut position, then turn the unit upside down to drain the recuperator chamber, also work the lever arm upwards and downwards to expel the old fluid from the working chamber. Now pour in paraffin and thoroughly flush both chambers, again working the lever up and down. Make sure that the paraffin is all drained out before refilling with the recommended fluid. To refill, inject with a clean oil-gun as much fluid as possible down the

adjusting-screw hole. Then replace the adjusting screw and adjust it to its original position. Refill the recuperator chamber and recuperate the working chamber by working the lever arm up and down as already described.

Loss of resistance will also occur if the bottom cover has worked loose, as this allows the fluid to pass around the end of the rotor vane. The bottom cover should be tightened as already described under "Fluid Leakage."

Adjustment

Each shock-absorber is adjusted in the makers' works to suit the car to which it is to be fitted, and it is advisable to retain this "setting" unless special conditions are to be catered for. If the original "setting" has been lost owing to the adjusting screw having been moved, an approximate adjustment may be obtained by screwing it down to the fully shut position and then slacking it back two complete turns. The best setting can afterwards be determined by road test with the shock-absorbers refitted. Turning the screw downwards increases the resistance and turning upwards decreases it. The screw is locked every one-sixth of a turn by a spring. The adjustment is very sensitive; therefore, do not move the screw more than half a turn at a time when making adjustments on the road.

Lever-arm Fixing

On certain types the lever arm is secured to the rotor shaft by a cotter bolt. Should the cotter work loose without damaging the shaft, a remedy may sometimes be effected by driving the cotter farther home and tightening the securing nut. In most cases, however, it will be found necessary to fit a new cotter. Replacements may be obtained from the manufacturers. A cotter flat is formed on both sides of the shaft. If it is found that the presence of a loose cotter has worn the flat on the shaft, the difficulty may be overcome by changing over the shock-absorber from one side of the car with that from the other, so that the cotter bolt will be located in the flat on the shaft which has not previously been used.

On other types the lever arm is mounted on a splined shaft and held on by a nut. Should an arm of this type work loose, it may be because the nut is not sufficiently tight, but if tightening the nut has no effect, the unit should be returned to the makers for repair.

The connecting-link bearings are of the same construction as those used with the piston-type shock-absorbers, and similar tools are used for their assembly.

SERVICE QUERIES

Before leaving this subject it will be of interest to consider some shock-absorber queries which may be received in service.

Complaints of Bad Riding

It is an unfortunate fact that a very large number of motorists have a completely mistaken idea as to the correct function of the shock-absorber, and if "the ride" of their cars is not just as they think it should be, they immediately attribute it to inefficient shock-absorbers. Most of our readers have probably met the type of man who will drive in and say, "My shock-absorbers are not working." On being asked for details, he makes a reply such as, "My wife felt sick when riding in the car on the way home from the coast last week-end." He has not troubled to check the resistance of the shock-absorbers, nor to check any of the other factors which have a pronounced effect on "the ride"—such as tyre pressures, shackle and spring lubrication, etc.—nor to make allowance for the human factor, in that both he and his wife were tired after a long day's run, but has assumed the shock-absorbers were not doing their job. It is, then, no good to accept a client's statement such as this, but it is necessary to investigate all the factors which influence the "ride performance."

Are Tyre Pressures Correct?

When describing the function of the shock-absorber we made a brief reference to the fact that the tyres form a part of the suspension system. It is not generally appreciated how important a part they play. The most perfectly sprung car may be made uncomfortable if the tyre pressures are not correct. One of the first items to check, when a complaint is received of "uncomfortable riding," is the tyre pressures; they should be in accordance with the car manufacturer's recommendation.

Other points, such as spring shackles, should also be looked at.

Testing Resistance of Shock-absorbers by Hand

The shock-absorber connecting links should be disconnected and the lever arms worked by hand. The resistance should be uniform in any one shock-absorber throughout the stroke of the lever and the near-side and off-side approximately the same. It should be noted that the word "approximately" is used. This is because when moving the lever by hand it can be moved at only a very slow speed; under these conditions the "feel" is influenced by such things as gland friction, etc., and the actual amount of hydraulic resistance which is exerted at road speeds may not be truly represented. Providing the resistance is uniform throughout the stroke and the off-side and near-side do not differ widely at hand speeds, they may be taken as satisfactory.

Standards of Ride Performance

Complaints of bad riding are often made by people who are expecting too high a standard and, on investigation, it is found that the performance of the car complained of is typical of that particular model, and is as the

car manufacturers intended. In many of these cases the customer is satisfied by the assurance that the various items concerned have been checked over and found correct, and a road test has shown that the ride performance is up to standard.

The garage engineer should concentrate on determining if the "riding" of the car is as its makers intended; that is to say, is it consistent with the performance of other cars of its type? It is not advisable to attempt to alter the characteristics of a car's suspension to meet an individual client's ideas without first pointing out that he is asking for a departure from the standard specification.

Investigating Noisy Shock-absorbers

Occasionally a car may be brought in with the owner complaining that the shock-absorbers are noisy. This needs carefully investigating. The bolts which secure the shock-absorbers to the chassis should be checked for tightness, and if the shock-absorbers are mounted on brackets, the bolts or rivets holding the brackets to the frame should also be examined. The anchorage of the lower end of the connecting links to the axles and the connecting-link bearings are further points which should be looked at. If the various bolts or rivets are tight, the shock-absorber connecting links should be disconnected and each lever arm moved by hand. If there is free movement of the arm it denotes lack of fluid and/or air in the pressure chambers. If this condition exists, a noise may be caused by the piston or vane "slapping" against the fluid after passing through the air-gap. The remedy is to "top up" with the recommended fluid and work the lever by hand to expel the air and recuperate the working chamber as already described. A case may be met with, however, where no free movement is present, or where "topping up" with fluid has dispelled the free movement of the arm and the resistance is uniform throughout the stroke—but the noise continues. Obviously a further search must be made. It is well known how difficult it is to locate a noise whilst driving, and the client may have been mistaken in his diagnosis. A simple method of determining if the noise is in the shock-absorbers or not is to take a short run on the road with each shock-absorber connecting link in turn disconnected. If a noise is present when one of the links is connected and absent when it is disconnected (and the fixing bolts are tight and the linkage correct), the noise is located as being in that particular unit. The noisy shock-absorber should be removed, and if it cannot be corrected by the usual maintenance methods it should be returned to the manufacturers, as some internal mechanical fault will have developed. A loose lever arm may also cause noise; the remedy for this is described under "Repairs."

A word here of the importance of expelling the air from the pressure chambers of the piston-type units before refitting them to the car. It is

imperative that all air is expelled by working the lever arm up and down through the full stroke, and, furthermore, after expelling the air, the unit must not be left lying on its side before fitting, otherwise air will re-enter. When all the air has been got rid of, the unit should straight away be bolted into its place or stood in its working position until it can be fitted.

" Rolling on Corners "

A further trouble which may be reported in the form of a shock-absorber complaint is " rolling on corners." It should be clearly understood that the shock-absorbers are not intended to act as an anti-rolling device. A little thought will show why this is so. We have already explained that hydraulic resistance increases with speed ; now, rolling is a slow movement, and this causes the shock-absorbers to offer only a low resistance, if they are adjusted normally. Assuming that they could be adjusted to offer sufficient resistance to prevent slow speed roll, the amount of damping for normal straight ahead conditions would be excessive and the result would be a very harsh, uncomfortable ride. The prevention of rolling does not come into the sphere of the shock-absorbers' duty. In fact, a large number of well-known car manufacturers are now fitting hydraulic shock-absorbers to damp the road springs and anti-roll torsion bars to prevent " rolling on corners."

REMOVING DENTS FROM WINGS AND PANELS

BY HOT-METAL SHRINKAGE

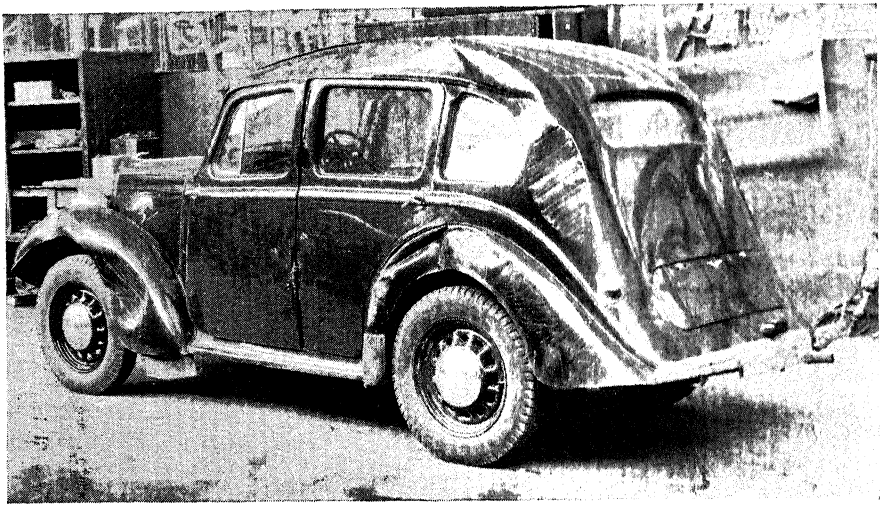


Fig. 1.—BODY WITH BADLY DAMAGED SIDE

A completely new side can be welded in after squaring up the body and cutting away the damaged parts. However, by the process of hot metal shrinkage, it is possible to repair damaged panels that might otherwise require replacement.

MODERN bodies with their welded panels and high-crown wings have hitherto presented a real problem in the repairing of damaged panel sections in which the metal has been stretched. The replacement of body panels is a long and tedious job, but by the use of the process of hot-metal shrinkage it is possible to repair damaged panels that might otherwise have required replacement. This process is particularly adaptable to high-crown wings—and this fact alone makes the mastering of this process well worth the time involved. The process of hot-metal shrinkage is the quickest, most simple, and most efficient method of restoring stretched body sheet metal to its original contour.

By a careful study of the process, step by step, and a little practice on old wings or body panels, hot shrinkage can be mastered in a relatively short length of time. We are indebted to the firm of General Motors Ltd. for the information upon which this article is based.

Where Hot Shrinkage can be Applied

Complete hot shrinkage can be accomplished only where it is possible to obtain a complete circular pressure around the stretched section of the metal. This can be done on all body panels, wings, and any high-crown panel. This circular pressure is created in a bound or anchored panel, or in a high-crown panel, when a damaged section is hammered out into the shape of a stretched bulge. Hood panels are the only body panels on which complete hot shrinkage is not assured. This is due to the fact that hood panels are of low-crown contour, and that they have no return flanges or inner construction by which the panels are supported, or to which they are anchored. Therefore, it is not possible to set up a complete circular pressure. For this reason it is possible to obtain only about 60 per cent. to 70 per cent. hot-shrinkage efficiency on unbound panels.

Hot shrinkage cannot be applied to sheet aluminium.

How Hot Shrinkage Occurs

After the metal has been hammered out into the form of a stretched bulge, heating a spot at the highest point of the bulge to a cherry-red heat releases the pressure at the centre and allows the shock of spring hammering to force the metal to upset, and also sets up a pressure opposite to the circular pressure.

With this opposing pressure set up, by allowing the metal to cool for about 10 seconds after the spring hammering, then quenching with a water-soaked sponge, the metal is forced into a circular draw, which draws it to the approximate shape of the original contour.

Some mechanics may have a tendency to become panicky when they see the heated spot begin to buckle and wrinkle upon applying the spring-hammer blows. However, the shock of these blows is what forces the metal to upset, and each time the heating, spring hammering, and quenching are applied to the stretched bulge, over half of the spring-hammered portion is drawn back, or shrunk, to its original contour. The kinks and wrinkles that appear so troublesome will rapidly be erased when the hammer and dolly block are used in the smoothing-out operation.

Instructions for Carrying Out Hot Shrinkage

For the purpose of explaining the process of hot-metal shrinkage, step by step, the following instructions, with their accompanying illustrations, will serve to clarify the process so that it is easily understood.

Fig. 2 shows the damaged section of the panel with the metal stretched and jammed inwards. It is apparent from the drawing that the metal has been stretched, and that in order to smooth out the panel to its original shape, something will have to be done with the stretched metal.

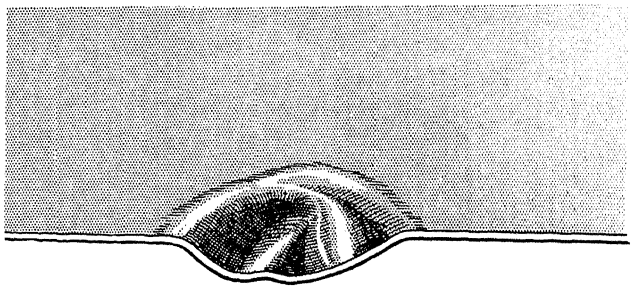
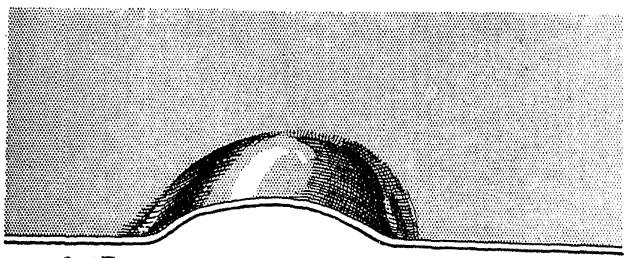


Fig. 2.—DAMAGED SECTION OF PANEL

The First Step—Roughing Out

The first step in the operation is to rough out the damaged section of the panel into the form of a stretched bulge, as shown in Fig. 3. This creates a complete circular pressure around the bulge, which is necessary to complete the hot-shrinkage process.

Next get a pail of water, a medium-sized sponge, and a mallet, and place them so that they may be easily and quickly reached when needed. This is most necessary, for the various steps in the operation must be done at the proper time, as very little time elapses between each step.



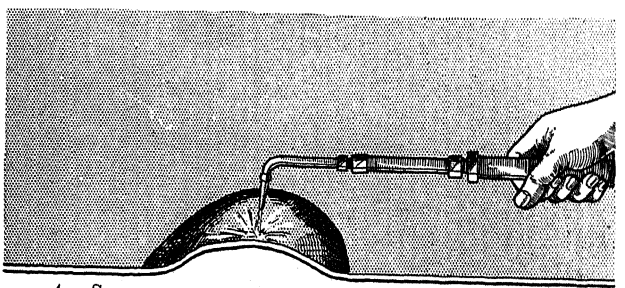
3.—FIRST STEP—DAMAGED SECTION ROUGHED OUT TO FORM A STRETCHED OUTWARD BULGE

Second Operation—Heating

Next heat a spot, about the size of a shilling, at the highest point of the bulge, to a cherry-red heat, as shown in Fig. 4. For this purpose use an acetylene torch with a small sheet-metal tip. Care must be taken not to get the metal too hot or it may be burned.

Third Operation—Spring Hammering

Then strike the hot spot about six quick, medium-hard blows with the mallet, Fig. 5. This forces the metal at the centre of the bulge to upset and drop down. *Do not* use a dolly block or any other backing-up tool while applying the blows with the mallet. The fact



4.—SECOND OPERATION—HEATING HIGH SPOT OF BULGE

that no backing-up tool is used is the reason for the term "spring hammering."

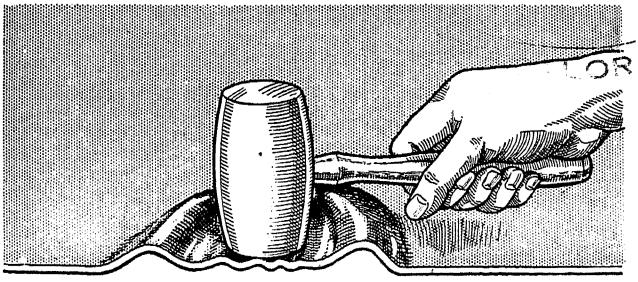


Fig. 5.—THIRD OPERATION—SPRING HAMMERING THE HOT SPOT

Fourth Operation—Quenching

Allow the metal to cool for about 10 seconds, then apply the sponge with all the water it will hold, pressing down hard on the spot that was heated and spring hammered. This is shown in Fig. 6.

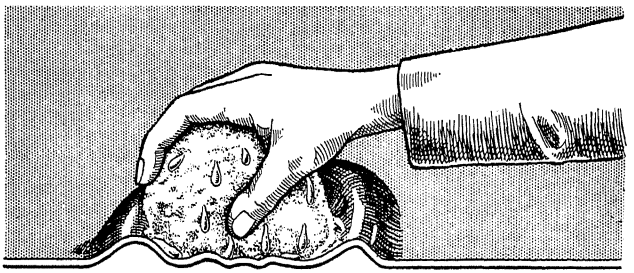


Fig. 6.—FOURTH OPERATION—QUENCHING THE HOT SPOT

Fifth Operation—Smoothing

After the panel has cooled, use a panel hammer and the proper dolly block to smooth out the shrunk portion of the metal, as shown in Fig. 7. This stiffens the metal and sets up pressure to aid in further shrinking. After this operation, the operator will notice that over half of the stretched bulge has been eliminated. The portion of the bulge that is taken out in any one heating, spring hammering, and quenching operation, will obviously depend on the size of the stretched bulge.

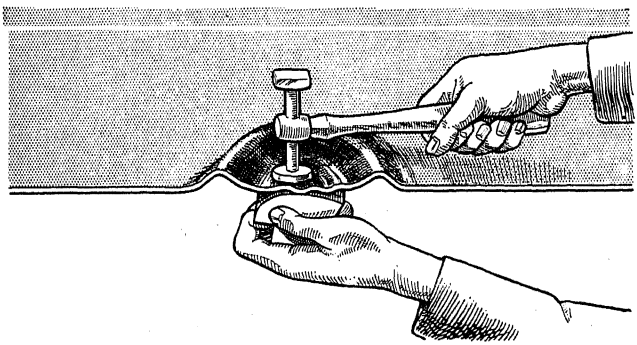


Fig. 7.—FIFTH OPERATION—SMOOTHING OUT SHRUNK PORTION OF METAL

Dealing with the Ridge

It will be seen from Fig. 8 that the shrunk portion of the metal is in the centre, and the remaining part of the stretched bulge is in the form of a ridge

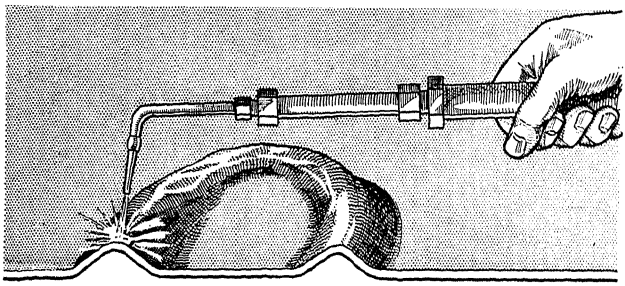


Fig. 8.—HEATING HIGH SPOT OF RIDGE

around the shrunk part.

Next heat a spot on the highest point of the remaining part of the bulge, about the size of a sixpence, to a cherry-red. This is shown in Fig. 8.

Then strike the heated spot about six quick, medium-hard blows with the mallet, as shown in Fig. 9.

Allow the metal to cool for about 10 seconds, then quench the hot spot by pressing the water-filled sponge on the spot, Fig. 10.

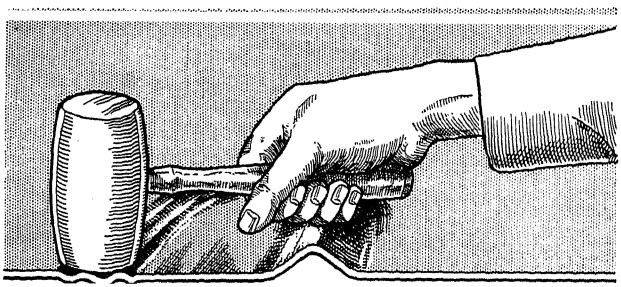


Fig. 9.—SPRING HAMMERING HOT SPOT ON RIDGE

Then, after the metal has been allowed to cool, smooth out this shrunk portion of the metal with a bumping hammer and dolly block, as shown in Fig. 11.

Completing the Work

On this particular job, this should leave only a small portion of the original bulge to be shrunk. Heat a spot about the size of a sixpence, at the highest point on the bulge, to a cherry-red heat, as seen in Fig. 12.

Give the heated spot about six quick, medium-hard blows with the mallet, Fig. 13.

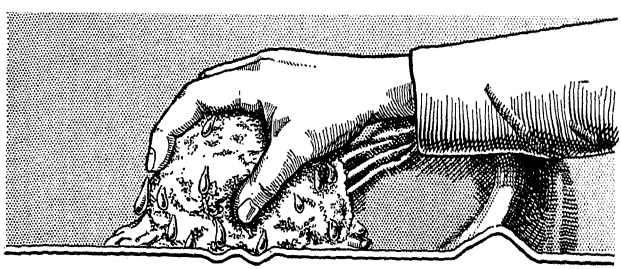


Fig. 10.—QUENCHING HOT SPOT ON RIDGE

Allow the metal to cool for about 10 seconds, then quench the spot with the water-soaked sponge by pressing it hard on the spot, Fig. 14. This will cause the remaining portion of the bulge to

wrinkle and drop down. It must be remembered, however, that the number of heating, spring-hammering, and quenching operations necessary to completely hot shrink the stretched bulge will depend on the original area of the bulge, a smaller area requiring less than a larger one.

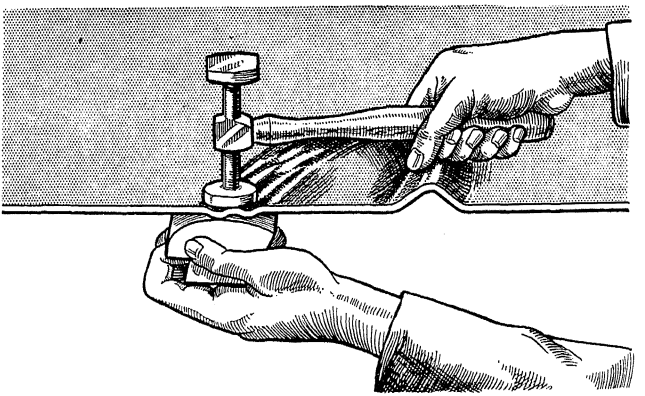


Fig. 11.—SMOOTHING OUT SHRUNK METAL ON RIDGE

Smooth out this remaining portion of the shrunk metal with a bumping hammer and dolly block. The damaged section of the panel is now ready for the finish smoothing out operation and metal finishing in preparation for the painting.

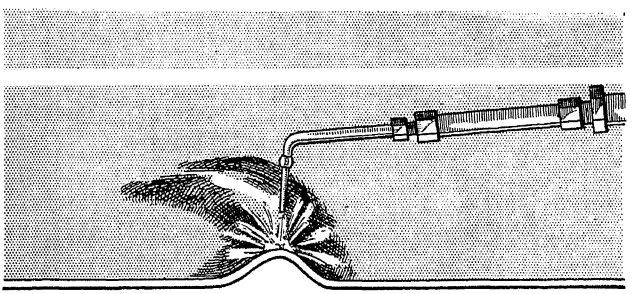


Fig. 12.—HEATING REMAINING HIGH SPOT

Some Final Warnings

Never quench the red-hot spot. Wait until the metal turns black.

Never heat the entire stretched bulge, or heat beyond the point of pressure. Use small heats.

Always hammer the stretched metal outward to form the circular pressure.

If the stretched part is very small, use a small heat.

Never use anything but an acetylene torch for heating.

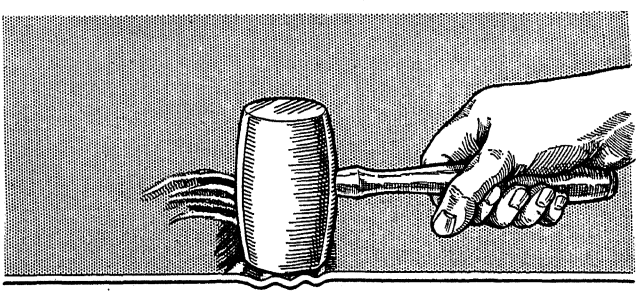


Fig. 13.—SPRING HAMMERING REMAINING HIGH SPOT

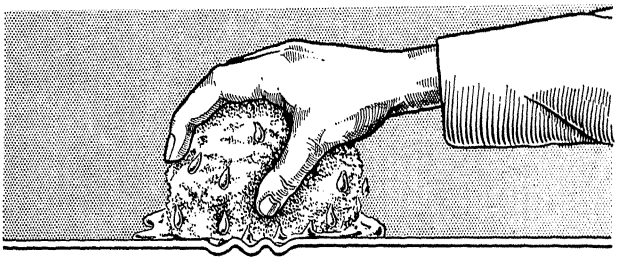


Fig. 14.—COMPLETION—QUENCHING HOT SPOT
Follow this by smoothing as in Fig. 11.

Never attempt to shrink a panel until after the roughing-out operation.

REPAIRING DAMAGED WINGS WHERE HOT SHRINKAGE IS NECESSARY

Wing repairing is not as difficult a job as the damaged metal might indicate. A good job is largely a matter of studying the damage and selecting the proper tools to work the dent out. The operator must always keep in mind the fact that the damaged section must be taken out the same way it went in. The reason for this is that when a wing is damaged, a backward strain—or strain contrary to that set up in the metal when the wing was formed—is set up. This strain must be relieved before the metal can be made to assume its original shape.

To clearly illustrate this job we take a wing that has actually been damaged and follow the steps in its repair, one by one. The wing seen in Fig. 15 is a rear wing that was damaged by being struck in the front, and in passing the car that did the damage pulled out the rear of the wing. The crown is jammed in, and the blow on the rear of the wing caused the outside flange to stretch. For convenience these damaged sections are numbered No. 1, No. 2, and No. 3, beginning with the front of the rear wing.

Cleaning the Damaged Wing

First clean the wing thoroughly with an oil-soaked rag. The purpose of the oil is: first, to reflect the light on to the damaged section, so that every bump and indentation may be readily seen; second, the oil creates a cushion under the hammer and keeps the paint from being picked up by the hammer.

Then clean the underside of the wing of all dirt and tar. If this is not done, the particles will be beaten into the metal when the hammer and dolly block are used.

Next place a piece of white paper on the floor and on it an electric light bulb in such a way that the light is reflected directly on that part of the wing on which the work is to be done. A good light on the damaged section is an *absolute necessity*, for it is obvious that a first-class job cannot be done if the operator cannot clearly see what he is doing.

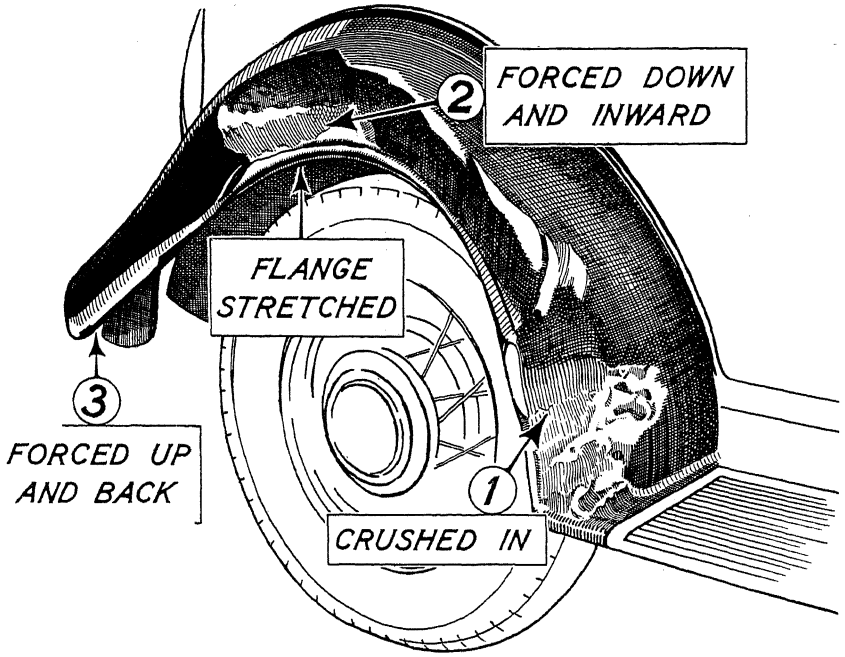


Fig. 15.—TYPICAL EXAMPLE OF REAR-WING DAMAGE
Method of repair by hot shrinking is described in the text.

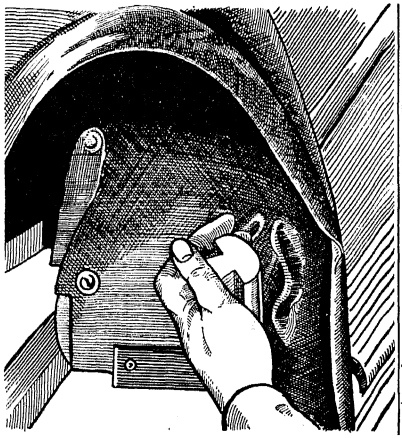


Fig. 16.—ROUGHING OUT DAMAGED SECTIONS OF WING, USING PROPER DOLLY BLOCK

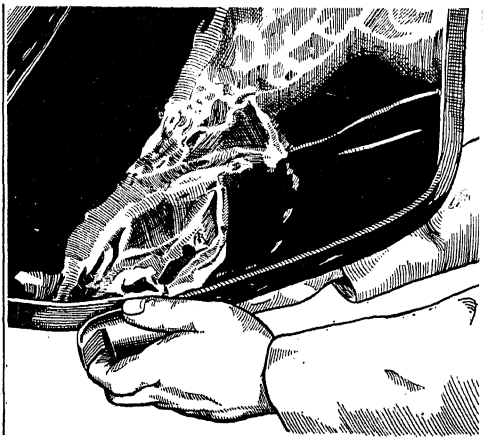


Fig. 17.—ROUGHING OUT SHORT, TIGHT DENTS

Roughing Out

Rough out dent No. 1, using the proper dolly block. Follow the crown of the wing when roughing out this dent. *Never* use a ball-peen hammer to rough out a damaged wing, or the metal will be full of small "bubbles," and a smooth job will be an impossibility. Selection of the proper dolly block will greatly simplify this operation, because the *right* block has the same contour as the wing had before it was dented.

Rough out the No. 2 dent on its natural position. Bring the crown back to its original position to form circular pressure in order to complete hot shrinkage.

The damage at the rear of the wing shows that the rear skirt has been pulled out and also that the rear corner section is pulled out, making a series of short, tight dents. The best method of roughing out short, tight dents is to use two dolly blocks, one held on the bead of the wing to relieve vibrations, and the other to rough out the dent.

After roughing out these tight dents bring the skirt back into alignment by holding a dolly block behind the low spot on the skirt and hammering the skirt back.

It will be noted at this point in the operation that the rear of the wing is loose and not rigid as it was before the wing was damaged. Hot-metal shrinkage at dent No. 2, in connection with pressure applied at the rear end of the wing, will not only shrink the stretched metal at this point, but will also draw the skirt of the wing in and make it rigid.

Hot Shrinking

To perform this operation, apply pressure to the rear of the wing, using a 2 × 4-in. length of wood as a lever. Then, in the centre of the stretched part of the crown, at the highest point of the bulge and about 2 in. up from the bead, heat a spot about the size of a shilling to a cherry-red heat. Never heat on the bead. Hit the spot about six quick, medium-hard blows with a mallet, and after allowing the spot to cool for about 10 seconds, quench by applying a water-filled sponge.

The pressure must be applied to the rear of the wing throughout the entire hot-shrinkage process. This is important.

If there are any breaks or cracks in the wing they must be welded before the hot-shrinkage operation.

Bump out the shrunk section, using a dolly block and a bumping hammer or mallet. Hold the dolly block loosely on the low spots underneath the wing, and strike the high spots on the outside with the hammer or mallet. This method causes the dolly to spring back against the low spots and readily smooth them out.

If the wing does not set square or is not shrunk enough, apply more pressure and repeat the process. Always heat on the highest part of the bulge.

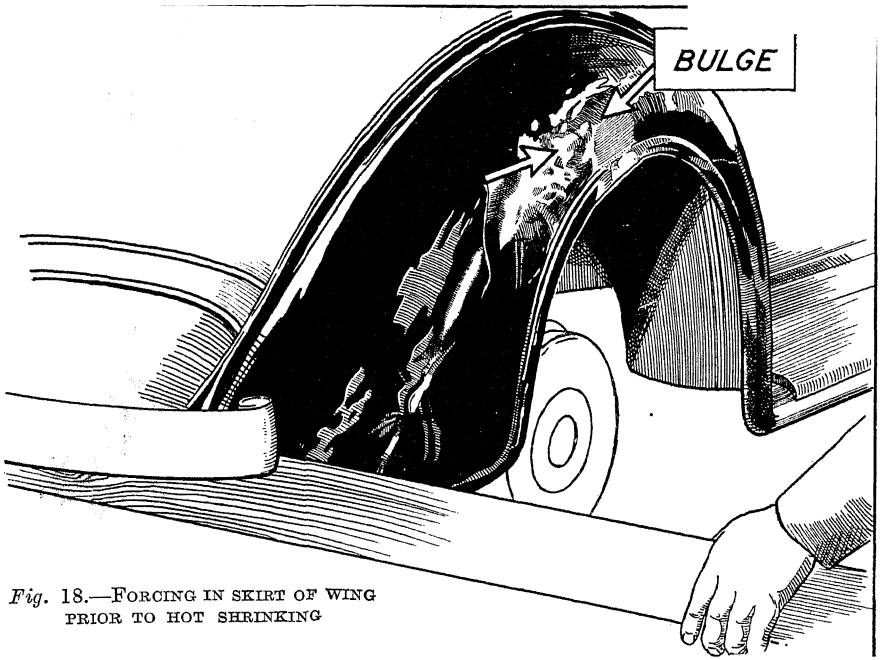


Fig. 18.—FORCING IN SKIRT OF WING PRIOR TO HOT SHRINKING

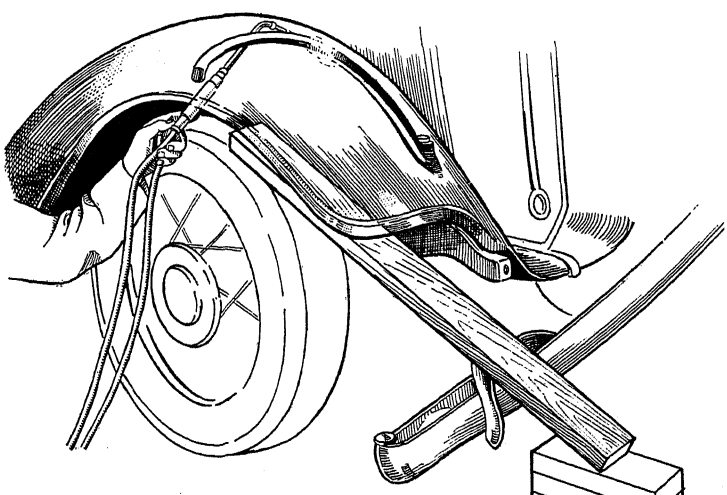


Fig. 19.—RELIEVING STRAIN AFTER FRONT-WING DAMAGE
Showing flange lined up while bracket is heated.

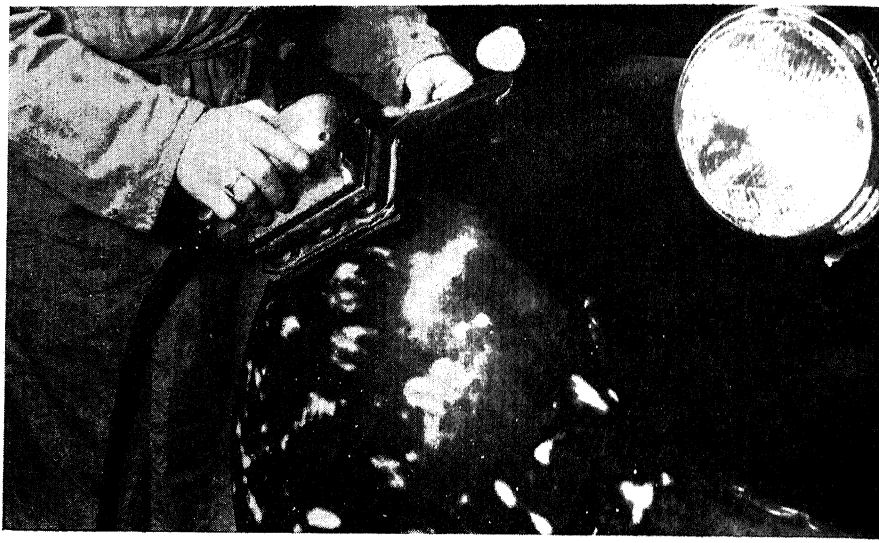


Fig. 20.—SANDER BEING USED FOR RUBBING DOWN ON A WING ("SPEED-BLOC" SANDER)
Methods of finishing are dealt with in another section of this work.

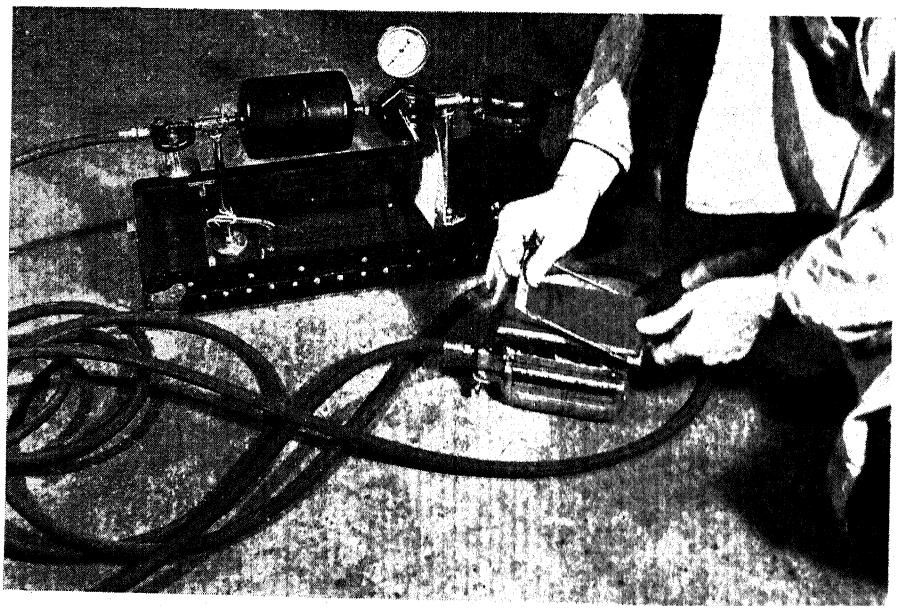


Fig. 21.—"SPEED-BLOC" SANDER
Showing the complete outfit and method of placing new paper on machine. (*Equipments, Ltd.*)

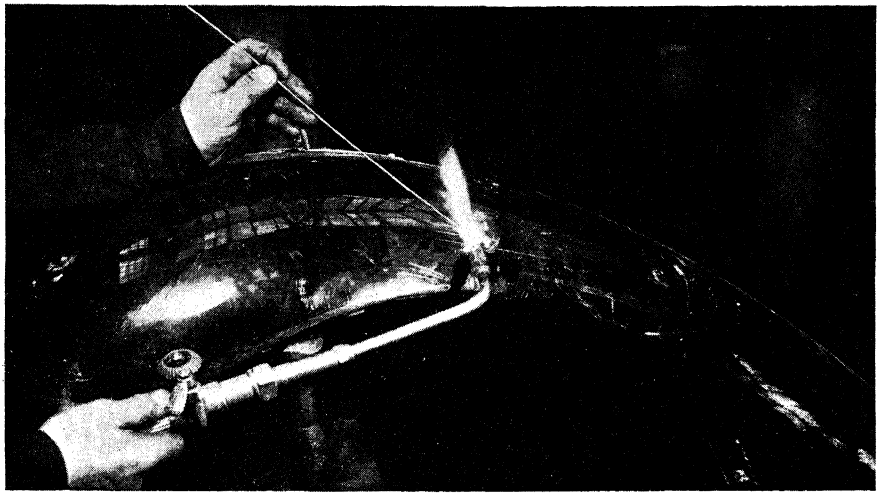


Fig. 22—SPLIT IN WING BEING WELDED

Breaks or cracks in wings must be welded before the hot-shrinkage operation. Welding repairs are dealt with in a later section of this work. (*Equipments, Ltd.*)

Aligning the Bead

To bring the bead into perfect alignment, hold a dolly block behind the low spots and strike the high spots on the bead with a mallet or bumping hammer.

To show up the high and low spots on the rough bumped sections use a long piece of chalk, and holding it flat on the metal, rub the chalk on these sections. The high spots will show up as being white with chalk, while the low spots will be dark or unchalked. Do not file yet.

Checking Smoothness

Finish bumping the sections by holding the dolly block loosely on the low spots and striking the high spots with a bumping hammer. Check the smoothness of the metal by rechalking—if a smooth job has been done the metal will show up as thoroughly chalked.

The metal may now be finished and prepared for painting with a file and disc sander. At the time the file is being used, any small indentations will show up and may be easily tapped out.

Front-wing Bead Split

Most front-wing damage is caused by a front end collision, or a blow directly on the front of the wing. It is not enough to simply repair the damage done to the wing, as the wing bracket is pushed back out of alignment at the same time that the wing is damaged. With this

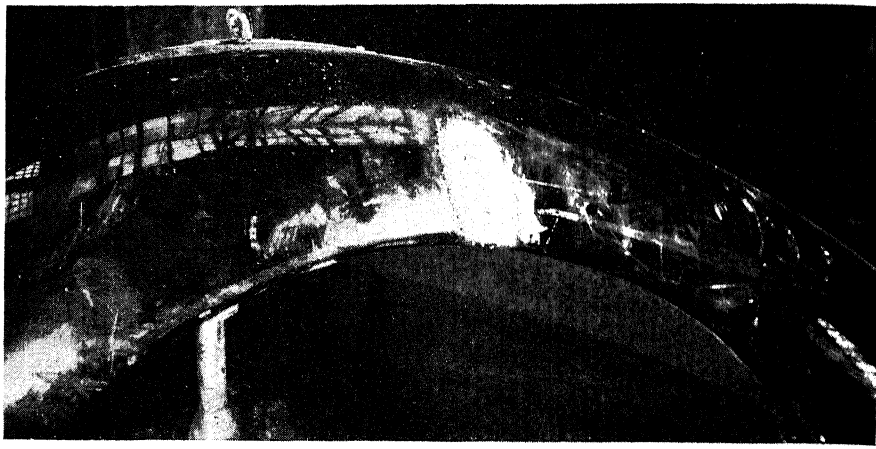


Fig. 23—WELD IN WING COMPLETED AND READY FOR REFINISHING

condition, all of the strain and weight of the wing is thrown on to the outside flange, or bead, causing the metal to split.

To relieve this strain, remove the bumper and place a 2 × 4-in. length of wood on the tyre and under the end of the wing, and pull up on the end of the wood until the bead of the wing buckles into its normal position. Then block the wood in this position. Protect the wing paint with wet asbestos. Heat to a cherry-red a spot about 2 in. long on the back flange of the wing bracket at a point approximately 14 in. from the outside edge of the wing. Also heat a spot about ¾ in. long on the forward flange of the bracket.

With the pressure still applied allow the bracket to cool. This will anneal the bracket, causing the strain to be relieved and preventing the wing from cracking at the bead.

When it becomes necessary to repair cracks that have been caused by failure to relieve the strain in the bracket, it is necessary to weld the break before the bracket is annealed.

Further methods of repairing damaged wings and panels are given later, in addition to methods of finishing.

SPECIAL POINTS TO BE WATCHED WHEN REPAIRING STANDARD CARS

PROPELLER SHAFT, REAR AXLE, FRONT AXLE, STEERING GEAR, ETC.

By B. TURNBULL

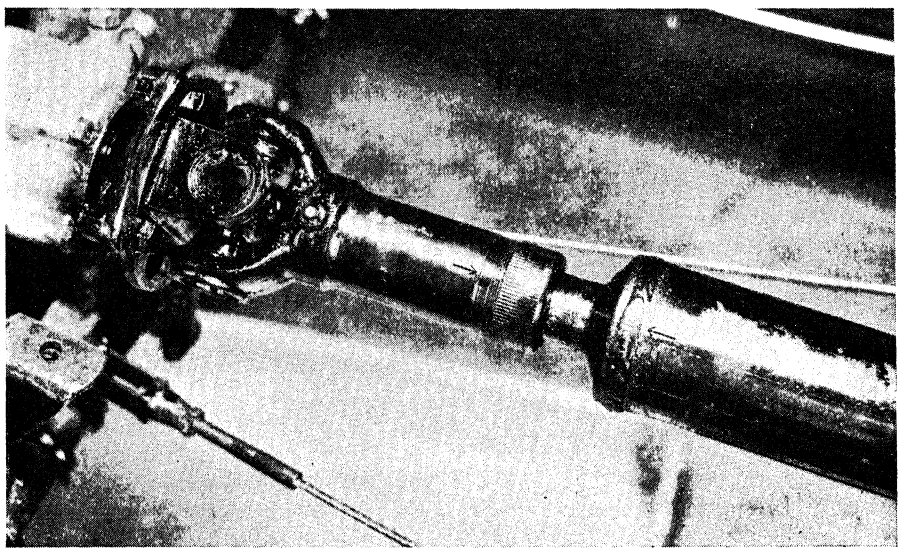


Fig. 1.—PROPELLER SHAFT

Showing arrow markings on propeller sleeve and shaft which must be in line to ensure correct alignment of yokes on axle of gearbox.

PROPELLER SHAFT

THE propeller shaft is a " Hardy Spicer " unit, and the yokes of the universal joints at each end of the shaft are carried on needle roller bearings and housed in steel cups which are filled with lubricant and are said to last the life of the car.

In the event of removing the propeller shaft from the chassis it is important that it be replaced with the sliding-yoke end towards the gearbox ; moreover, if the sliding yoke has been removed from the splines at the end of the shaft it must be replaced again in its original position. This position is indicated by two arrows, one of which is on the body of the

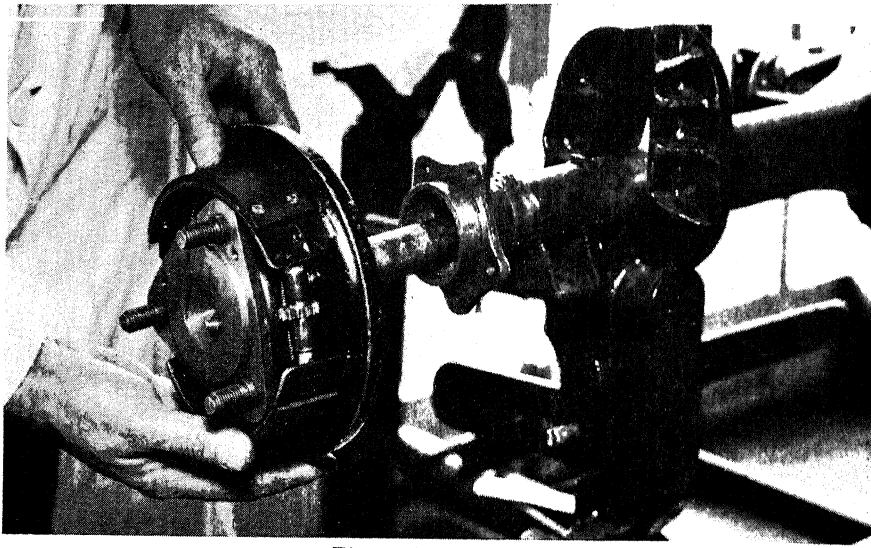


Fig. 2.—REAR AXLE
Withdrawing one-piece rear axle, half shaft and hub.

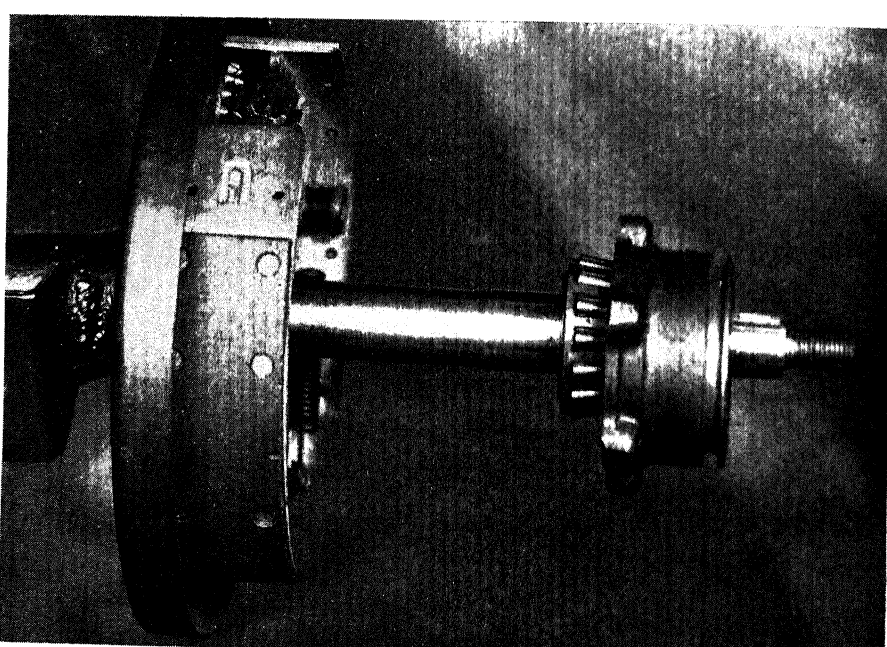


Fig. 3.—REAR AXLE
Removing rear-axle shaft and taper bearing with housing, after withdrawing hub.

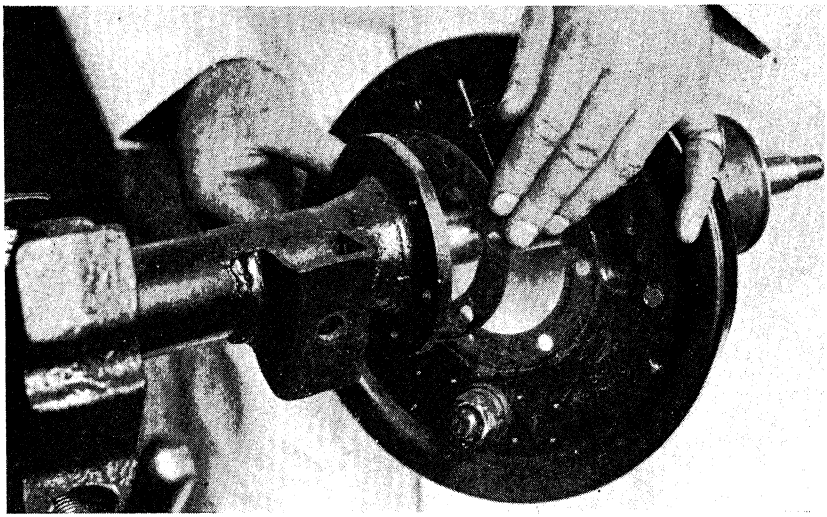


Fig. 4.—REAR AXLE
Fitting packing shims for bearing clearance.

sliding yoke and the other on the body of the shaft. These arrows must be in a line with each other when the sliding yoke has been replaced on the end of the shaft.

REAR AXLE

The rear axle is the orthodox semi-floating type of unit employed on all models, and the chief variation that may be found in respect of the different models is the dimension. However, on the 9-h.p., 10-h.p., 12-h.p., 14-h.p., and 20-h.p. axles the axle shaft and the hub are separate, but on the 8-h.p. axle the shaft and the hub are combined and the hub is therefore not detachable. If, therefore, the hub on the 8-h.p. model becomes damaged through accident or other causes it will be necessary to replace the shaft and the hub.

To Dismantle Rear-axle Unit

To dismantle the rear-axle unit on any model proceed as follows :

(1) Jack up the rear of the car and remove rear road wheels and brake drums.

(2) Disconnect rear brake cables from brake cross-shaft.

(3) Remove nuts and locknuts from rear axle U-bolts and extract bolts and disconnect the plate carrying the pin to which the shock-absorbers are connected.

(4) Disconnect propeller shaft from rear axle.

(5) Remove split pins and undo the nuts and bolts holding brake backing plate to each end of the axle casing.

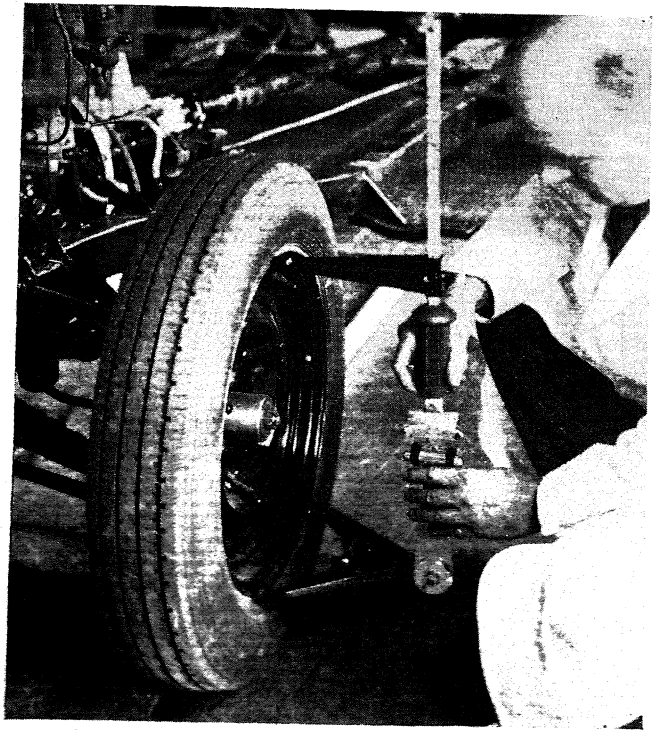


Fig. 5.—CHECKING CAMBER WITH CAMBER GAUGE

The position of the front wheels should be either perpendicular or with a positive camber of ½ degree (independent suspension).

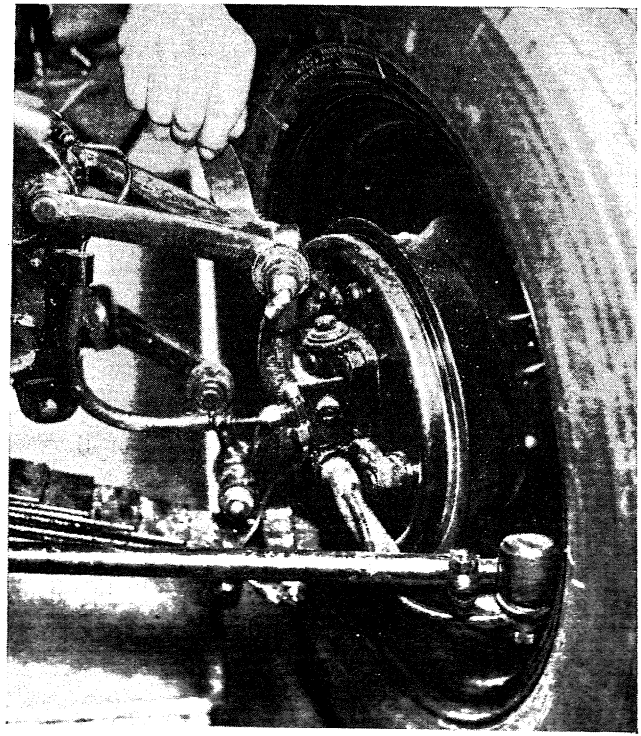


Fig. 6.—ADJUSTING CASTOR ANGLE

Adjusting eccentric bush on front shackle for setting the castor angle. This should be between 1½ degrees and 2½ degrees (independent suspension).

(6) Pull out axle shafts, together with hub bearing, bearing housing, distance shims, and brake backing plate.

(7) Remove nuts and washers which hold the pinion housing in position and withdraw the housing complete with differential.

Fitting New Pinion and Crown Wheel

In the event of having to fit a new pinion and crown wheel the differential will have to be dismantled. It will save the operator time, however, if, during removal of the pinion, the two collars which are known as the bearing adjuster and the adjuster collar be left in their original positions, for by removing the flanged coupling from the pinion shaft the pinion may be ejected from the housing without altering the position of any of the other details. This will act as a guide when inserting the new pinion, which will in all probability take the same position as the old pinion and therefore eliminate the time which is quite frequently spent in endeavouring to adjust the pinion and the crown wheel. When the pinion is inserted in its correct position the end of the pinion teeth should be in line with the inside end of the teeth on the crown wheel, and the backlash existing between the teeth of these two gears should be approximately ·005 in.

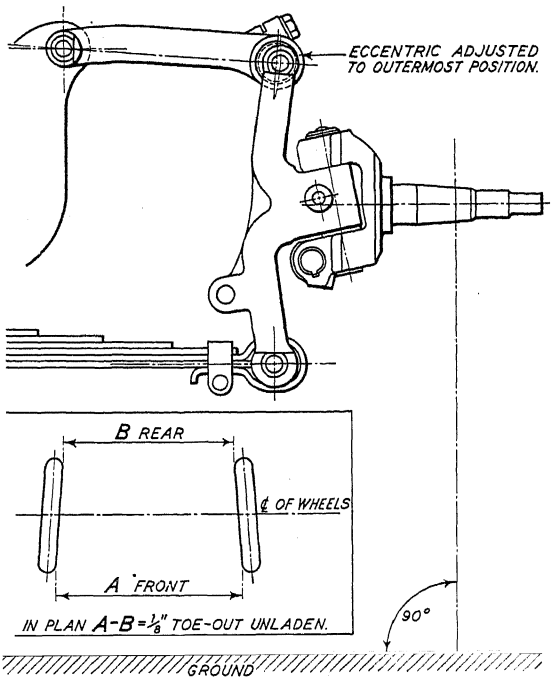
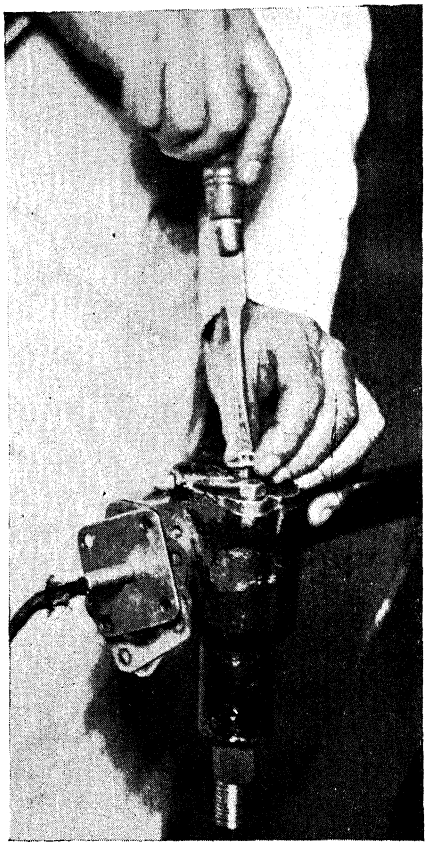


Fig. 7.—INDEPENDENT SUSPENSION ALIGNMENT (ALL MODELS)

It is desirable that wheels be vertical or slightly cambered (outwards at the top). This is usually achieved when the eccentric adjuster is set as shown above. Half degree camber is quite sufficient. Accurate measurements cannot be made if suspension joints are stiff. The castor angle should be between 1½ and 2½ degrees. A small amount of adjustment is available by screwing in or out the eccentric bush shown above.

Axle Shaft End Float

On replacing the axle shafts on all models, with the exception of the "Eight," the end float on the axle shafts should be adjusted to ·006 in.



'. 8.—STEERING GEAR

Adjusting cam and roller between end cover and box. Note the shims.

FRONT AXLE ASSEMBLY

Re-straightening Axle Beam

The front axle assembly, with the exception of the 8-h.p. and 12-h.p. Super 1939 models, is an orthodox arrangement with the usual axle beam, semi-elliptic springs, stub axles, etc. The axle referred to consists of a 60-ton alloy steel beam, and the important point in connection with it is that in the event of its being bent as the result of a collision, it is essential that when it is straightened it must be re-heat-treated. There can be no departure from this procedure, as failure to do so would reduce the strength of the material, thereby considerably reducing the margin of safety.

Correct Castor Angle of Axle Beam

The axle beam has a castor angle of about 4½°, and this is, on some models, obtained by the insertion of suitable wedges between the spring platform on the axle beam and the road spring.

It is therefore advisable, when dismantling this assembly, to carefully observe the manner in which these taper wedges were originally fitted, so that they go back in exactly the same way. If the taper wedges are fitted incorrectly they are likely to produce either wheel wobble or a tendency for the car to wander. When the wedges are fitted correctly, the king pins at the end of the axle beam should be canted backwards between 2½° and 4½°.

Another important point in connection with the front of the Standard car where the orthodox suspension is employed, is that the track of the front wheels is parallel. Experience shows that this gives the best results, with regard to both stability and tyre wear.

Independent Suspension

On the 8-h.p. and 12-h.p. Super 1939 models there has been introduced a form of independent suspension at the front of the car. This has been

achieved by the aid of a transverse road spring, the ends of which are coupled to the frame through the medium of a swing shackle and an H-section bracket which carries the stub axle. The stub axle itself is orthodox in design and carries "Timken" races which support the hubs and road wheel.

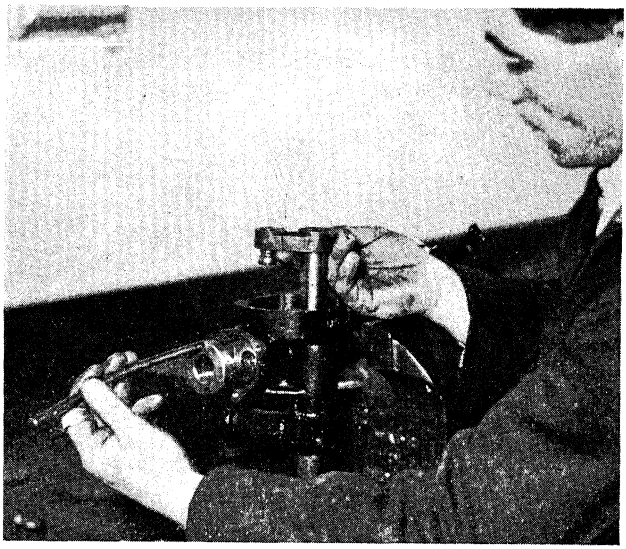


Fig. 9.—METHOD OF REMOVING STEERING SHAFT

The track of the front wheels on this model varies with that of other models, which have orthodox suspension, inasmuch as the two front road wheels toe out at the front $\frac{1}{8}$ in. The castor angle should be between $1\frac{1}{2}°$ and $2\frac{1}{2}°$, and a small amount of adjustment is available by screwing in or out the eccentric bush shown in Fig. 7. The position of the front wheels should be either perpendicular or with a positive camber of $\frac{1}{2}°$. An eccentric bush is provided at the outward end of the swinging shackle and is retained in position by a clamp bolt, and adjustment of the road wheel position so far as the camber is concerned is also provided by adjustment of this bush.

STEERING GEAR

Remedying Wear in "Douglas Burman" Gear

The "Douglas Burman" steering gear is part of the specification of the 8-h.p., 9-h.p., and 10-h.p. Standard cars. It is a nut and worm arrangement, and is so satisfactory in use that no special adjustments are required. After a considerable mileage, however, it is possible for wear to occur on the worm and nut of the steering gear, in which case it is necessary to replace both worm and nut, which are supplied in pairs suitably fitted together. To fit a new nut on an old worm is unsatisfactory, as experience shows that wear which occurs on the worm is concave so that you have the maximum wear in the centre of the worm. If the new nut is adjusted so that it is the correct fit in the centre of the worm the steering will be too tight on the extreme locks, whereas if you adjust the nut to be a fit at the ends of the worm it will in all probability be too slack in the

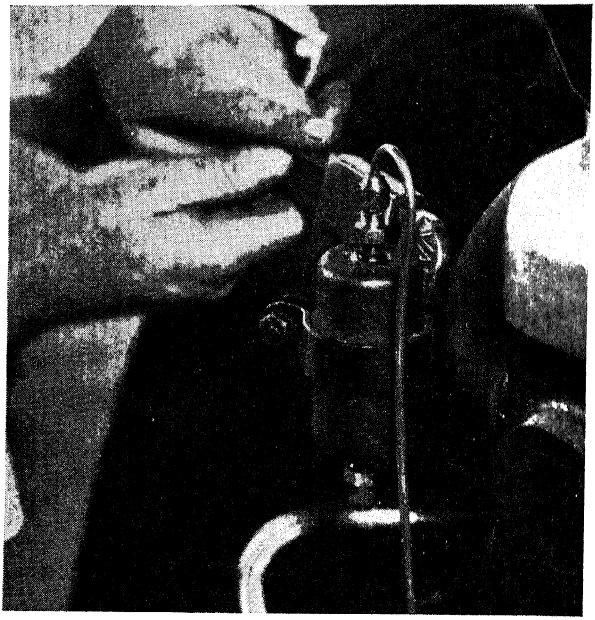


Fig 10.—THERMAL CHASSIS LUBRICATION

Adjusting oil supply by moving expansion chamber nearer or farther away from manifold.

centre, therefore in all cases it is important that a new nut and worm be installed.

Adjusting "Marles" Gear

On the 12-h.p. 1939 model the "Marles" steering gear is in use, and the chief point of importance to observe is that when adjustment is necessary the position of the roller in relation to the cam should be adjusted when the roller is in the centre of its range of movement. The adjustment is carried out by the eccentric bush, which raises and lowers the roller, and the roller should be adjusted so that there is practically no backlash when in the centre of the cam, but it will be observed that at the extreme locks there is backlash present between the roller and the cam and this should be equal at both extreme locks.

Adjustment of "Bishop" Steering Gear

The 14-h.p. and 20-h.p. Standard cars have the "Bishop" steering gear as part of the specification. This steering gear is of the cam and lever type, and to ensure complete freedom throughout the entire range of movement a small amount of end float is provided on the rocker shaft. Underneath the lid of the steering box there are placed a number of thin shims, for adjustment of the rocker shaft end float in the event of wear occurring on the cam or on the pin extension of the rocker shaft which engages with the cam. Too much end float provides an excess of free movement on the steering wheel, whereas insufficient end float may cause binding at certain parts of the steering. The amount of end float which is desirable is between ·006 in. and ·010 in., and the adjustment should be made accordingly.

Replacing Steering Drop Arm Correctly

With regard to these three types of steering assemblies there is one important point which is common to all three, and that is to ensure that in the event of the drop arm being removed from the steering rocker shaft care should be taken to ensure that it is replaced in its original position. In those models which have the orthodox suspension the extent of the steering lock is controlled by stops which are fixed to the end of the axle beam, and against which the stub axles make contact. If the steering drop arm is replaced on the rocker shaft incorrectly it is more than likely that there will be a large lock on one side of the centre of the turning circle and a short lock on the other side. This will mean that on one lock the stop is actually occurring inside the steering box, and apart from the difficulty of being unable to obtain adequate steering owing to a short lock, there is also the possibility of damage occurring to the steering gear.

On the models which have independent suspension the steering stops are obtained by setscrews and locknuts which are screwed into the vertical brackets which carry the stub axle. These stops are therefore adjustable, and should be set in such a fashion that there should be a little further movement in the steering box by the time the steering stops have come into action.

THERMAL CHASSIS LUBRICATION

The steering assembly, with the exception of the steering box itself, on the 12-h.p. models with independent suspension, is lubricated by an automatic system of lubrication described as the "Bijur" automatic lubrication system. This consists of an expansion chamber, and is supported by a bracket adjacent to the exhaust manifold. The chamber is filled with oil from a gravity feed tank, and the heat of the engine causes the oil in the expansion chamber to expand and pressure is therefore created through the pipe-lines leading from the outlet valve of the chamber to the various steering points which require lubrication. This cycle of operation is carried out automatically each time the engine reaches its normal temperature and then cools down, but the efficiency of this lubrication depends upon the system being correctly primed with oil.

Priming the System with Oil

It is therefore important that the priming is carried out properly, and the following is the correct method of carrying this out :

(1) Check the oil level in container.

(2) Disconnect pipe from the bottom end of the expansion chamber and plug this pipe to prevent oil loss from the container.

(3) Apply priming pump or gun to the bottom end of expansion chamber and force oil through the expansion chamber and along the pipe-lines.

(4) During this operation examine the system for heavy or rapid leakages due to either loose connections or broken pipes.

(5) Continue priming until oil is seen exuding from each and every point in the system.

Failure of Valves in Expansion Chamber

It is possible through the introduction of foreign matter for the valves in the expansion chamber to be put out of action, thereby affecting the efficiency of the system, but this may be corrected by disconnecting the pipes from each end of the expansion chamber and unscrewing the valves. The valves should be washed in petrol, and to ensure that the expansion chamber is clean it should be swilled out with petrol also. When replacing the valves it is important that the joints are airtight, and it is therefore recommended that a jointing compound should be used, such as "Hermatite." It is, of course, necessary to remember that when failure occurs at any point of the system satisfactory results can only be obtained on re-priming the system in accordance with the foregoing instructions.

The oils which are recommended for use with this thermal chassis lubrication system are: Essolube Gear Oil Medium, Patent Castrol XXL, Mobiloil BB or CW, and Golden Shell Extra Heavy.

REPLACING ROAD SPRINGS

The road springs at the rear of Standard cars have incorporated silentbloc bushes in the eyes at both ends. This necessitates a different procedure when fitting replacement springs, as it is important that the shackle bolts be not tightened until the weight of the car is on the spring, when the shackle bolts should be tightened up solidly. The spring deflection and extension is arranged for by torsional movement of the rubber in the silentbloc bush, and this rubber should move to the same extent radially from a given zero position. This zero position is determined by the position of the spring when the weight of the car is on it and before the shackle bolts are tightened. Neglect of this precaution may result in overloading the rubber in the silentbloc bush, and therefore reduce its working life.

SERVICING LANCHESTER CARS

REAR AXLES, BRAKING SYSTEM, FRONT SUSPENSION, AND STEERING GEAR

By A. SQUILLARIO

THE REAR AXLE

Lanchester 10-h.p., 11-h.p., and 14-h.p.

FIG. 2 is an illustration of the section of a rear axle as fitted to these models.

To dismantle, remove the nuts holding the axle tubes to the axle casing and knock off the tubes complete with hubs and axle-driving shafts. It will be noted that the axle-driving shafts are splined at both ends and are a push fit in the differential but are secured to the hubs by nuts. In service these nuts should have periodical attention, as it is essential that they be kept perfectly tight.

The top cover of the case is then removed together with the nuts securing the bearing caps. Draw the caps of the studs and lift out the differential and worm-wheel assembly.

Remove the nut from the coupling flange also, the nuts holding the worm-shaft covers. Remove flanges and draw out worm shaft complete from the front end.

Assembly

The worm shaft is located by the front ball race, which is of the deep-track type, taking thrust as well as journal load. No adjustment is required or provided, the adjusting washer being standard.

The adjustment of the worm wheel is by means of sleeves (see Fig. 2). In fitting a new worm wheel, straps are placed over the axle-tube studs and tightened or let

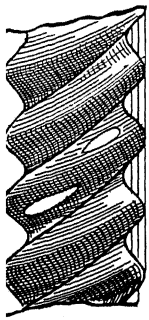


Fig. 1 (*Right*).—HOW TO TEST ACCURACY OF ASSEMBLY (LANCHESTER 10-H.P., 11-H.P., AND 14-H.P.)

Coat the worm with marking black, and bolt up in position. Two adjacent worm-wheel teeth have an indelible marking put on them to show where the worm must bear. On the worm being slowly rotated by hand, it can be at once seen if the assembly is correct.

Fig. 2.—REAR AXLE ON LANCHESTER 10-H.P., 11-H.P., AND 14-H.P.

off until the worm wheel is correctly positioned according to marking, as shown in Fig. 1. The amount of sleeve then projecting beyond the joint face is then measured and the sleeves adjusted until the ends are just flush with the joint face.

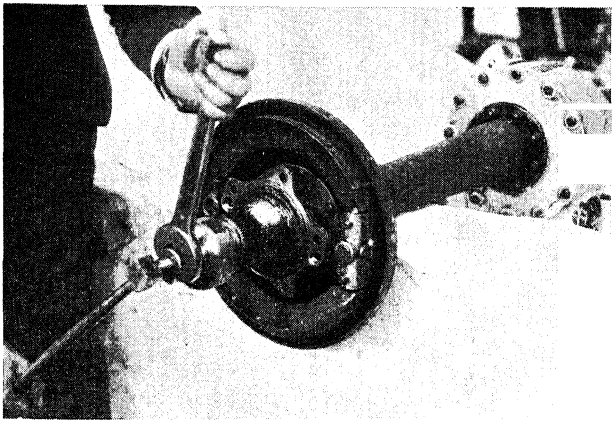


Fig. 3.—USE OF THE HUB EXTRACTOR

Lanchester 18-h.p.

On the axle fitted to this model the near side axle tube is attached to the main cover.

The use of a hub extractor is necessary, as shown in Fig. 3. Remove the nuts holding the axle tubes to the casing and draw the tubes off the studs. Remove setscrews securing the cover plate on the near side of the axle case.

Draw out the differential case housing on the offside of the axle casing, using special extractor as shown in Fig. 4. This operation will give sufficient clearance to enable the differential and worm-wheel assembly to be tilted so that it can be withdrawn through the aperture on the near side, after the cover plate has been eased from the casing, to which it is spigoted. Do not attempt to force out the assembly, as damage may be caused to the teeth of the worm wheel.

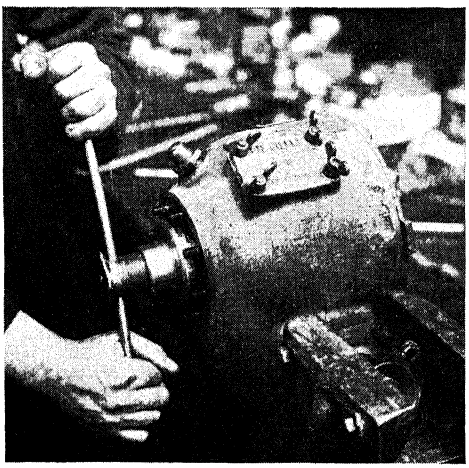


Fig. 4.—LANCHESTER 18-H.P.

Drawing, by means of extractor, differential housing on Lanchester 18-h.p. axle case on the off side.

To dismantle the worm wheel and differential assembly, remove the locknut from the Timken races and draw off the large cover plate. Remember to note the order of assembly of these races, as they must be reassembled paired as before. Remove bolts from the worm wheel and differential case and

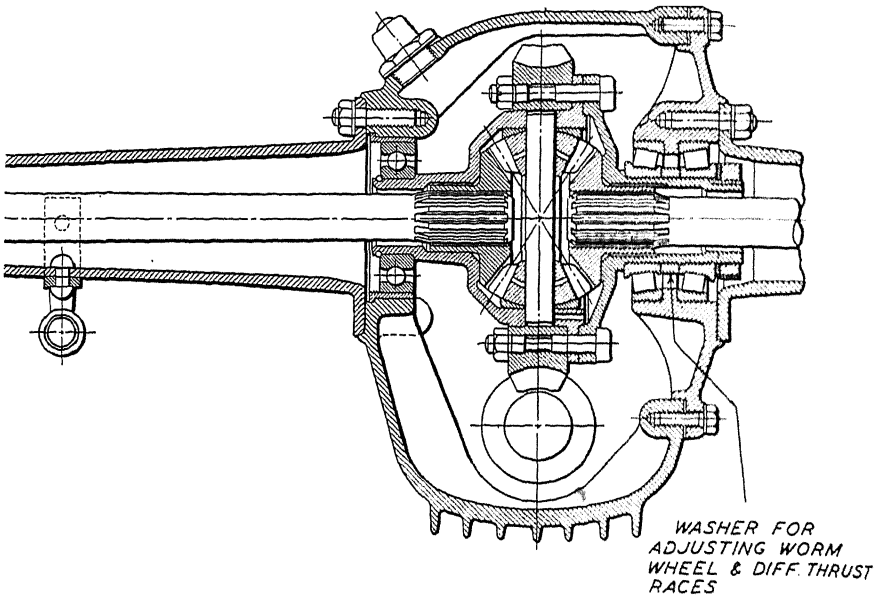


Fig. 5.—LANCHESTER 18-H.P. REAR AXLE ARRANGEMENT

Showing the washer, the thickness of which is varied for adjustment of the differential and the worm-wheel unit.

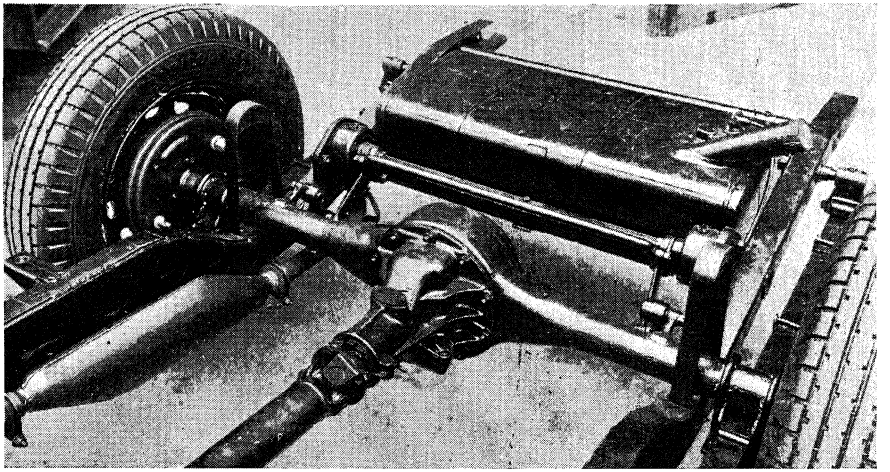


Fig. 6.—LANCHESTER 14-H.P. REAR AXLE IN POSITION

part them. The differential pinions, pin, etc., can be taken out.

To remove the worm shaft, take off the nuts from the front and rear cover studs, and draw the driving jaw off the splines on the shaft, after removing the split pin and securing nut.

Assembly

Fit the worm shaft in the casing and assemble the differential and worm-wheel unit. The adjustment of the latter is controlled by the twin tapered roller bearings and is effected by varying the thickness of the washer between the two inner races. The assembly should revolve freely on the races without any lift after tightening up the locknut (see Fig. 5).

The order of dismantling may now be reversed ; but if any new parts have been fitted, the position of the worm wheel must be checked. The adjustment of the worm wheel is varied by means of shims between the axle casing and the large cover plate.

Examination of Parts

Worm and worm wheel should be carefully examined, and if the worm wheel is worn, it should be returned to the makers. It can then be re-cut and paired with the existing worm.

Particular attention should be given to felt washers, and it is advisable to fit new ones when assembling. After axle has been assembled and tested, examine worm shaft gland and all joints for leakage.

THE REAR AXLE AS FITTED TO LANCHESTER 14-H.P. DE LUXE

Adjustment is provided for the setting of both the crown wheel and pinion, but unless the assembly has been dismantled for any reason, no

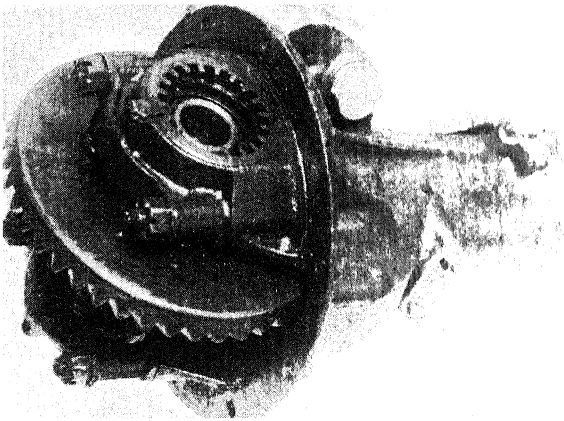


Fig. 7.—E.N.V. REAR AXLE, LANCHESTER 14-H.P. DE LUXE

adjustment should be necessary.

To Dismantle

Remove split pins and nuts which secure differential journal bearing caps. After removing bearing caps, the differential assembly can be withdrawn complete, and can be dismantled in the usual way by removing differential case bolts which secure the crown wheel.

Remove split pin and nut which secure the coupling to the front end of the pinion shaft, then press out the pinion through the bearings. The thrust bearing and the outer ring of the roller bearing will remain in the housing. The thrust bearing can be pressed out after the adjuster ring at the front end has been removed. The outer ring of the roller bearing can be pressed out towards the rear of the casing. The thrust bearing inner adjusting ring can then be screwed out if required.

To Reassemble

Screw thrust bearing inner adjusting ring into position in the housing, and press in outer ring of roller bearing, being careful to place the lip of this ring towards the front end. Insert thrust bearing and $\frac{1}{8}$-in. washer, and screw in outer thrust bearing adjuster ring.

After placing pinion-head washer in position, press the inner ring of the roller bearing on to the pinion stem. Place bearing

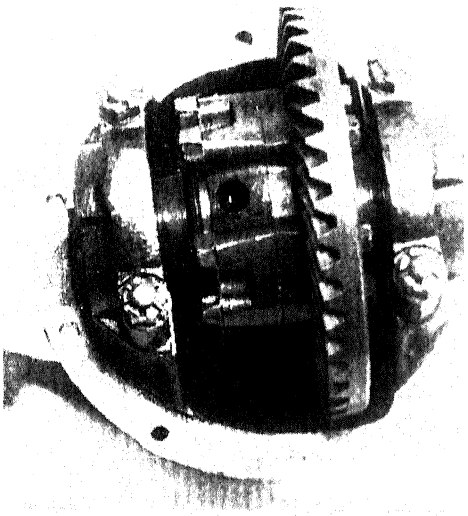


Fig. 8.—E.N.V. REAR AXLE, 14 H.P. DE LUXE

distance piece on the pinion and press the pinion into the housing, making sure that the $\frac{1}{8}$-in. washer mentioned previously is in position.

After reassembling differential case and crown wheel, check the latter for running true. The wheel should not run out more than 0·003 in. when measured on its back face and at its greatest diameter. Place assembly in position and tighten bearing caps sufficiently to grip the side adjuster ring nuts, but not tight enough to lock them.

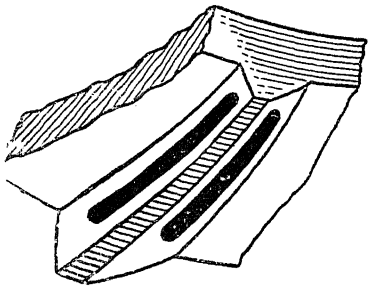


Fig. 9.—BEARING REQUIRED (UNDER NORMAL CIRCUMSTANCES) FOR 14-H.P. LANCHESTER DE LUXE REAR AXLE

When meshing the gears, care must be taken to engage the teeth in the position marked on the crown wheel and pinion. To adjust the gears to their best running position, the teeth should first be painted with a mixture of red lead and oil or some other suitable marking. The correct tooth contact extends from the small end of the tooth to approximately two-thirds of its length, and from the top of the tooth to its root (see Fig. 9), and is obtained by moving the position of the pinion by means of the two adjusting-ring nuts.

A thin-line contact at the root of the teeth of the crown wheel should be avoided. When the pinion is adjusted away from the crown wheel, the bearing contact will move away from the root of the crown-wheel teeth, and vice versa. The correct backlash between the gear teeth is from 0·004 to 0·006 in., when measured at the outside diameter of the crown wheel, and is obtained by adjusting the two adjuster-ring nuts at the side of the differential assembly. The adjustment of the pinion must on no account be moved to alter backlash.

After the gears have been set correctly, tighten the bearing-cap nuts and insert split pins. Fit locking pieces to pinion adjuster-ring nuts.

THE BRAKING SYSTEM

The early type 10-h.p. and 15/18-h.p. were fitted with hydraulic-operated brakes, the latter model being servo-assisted.

Adjustment

Adjustment is simple, the only tool necessary being a $\frac{3}{8}$-in. spanner. Jack up offside front wheel and screw the two adjuster nuts outwards until each brake shoe is just touching the brake drums. Now screw adjuster nuts inwards slightly until the wheel is just able to rotate perfectly freely. Repeat this operation for remaining wheels in following order: nearside front, offside rear, and nearside rear. When the foot-brake is fully applied, the minimum safe clearance between the pedal and

the floorboard is 1½ in. When the clearance is reduced to more than this amount, further adjustment is necessary.

To bleed the System

The process of bleeding the system should only be necessary after some part of the braking gear has been dismantled or the level of fluid in the supply tank has been allowed to fall so low that air has entered the pipes. Remove bleeder screw from offside front wheel and screw in bleeder tube. Allow the end of the tube to hang in a glass container. The supply tank should be kept about three-quarters full during the operation. Unscrew bleed valve one half-turn and push down brake pedal slowly and allow to return to the "off" position. Repeat this a number of times until all the air is expelled from the system, which is ascertained when bubbles cease to appear in the glass container. With the pedal still pressed down, tighten bleed valve. Repeat on the other wheels in the following order: nearside front wheel, offside rear wheel, and nearside rear wheel. Use only official-type hydraulic brake oil as recommended by the makers.

The Girling Mechanical Brake

Fig. 10 illustrates the layout of this type of system. Adjustment is very simple and is effected by turning adjuster nut. Do not touch split-pinned cone-housing nuts, as it is intended that the housing should be allowed to float to a limited extent.

Accurate adjustment can be made without jacking up the wheels by rotating the adjuster nut until it will turn no more. (The shoes are then up against the drum.) Turn the nut back until the flats of the cone are felt to be in engagement with the brake-shoe pivots. At this point the required clearance of 0·015 in. on each shoe is obtained.

The Bendix Brake as fitted to Lanchester 14-h.p. de Luxe

Wear is taken up by centralising the two shoes in the drum by means of the eccentric centraliser and expanding them in the drum by means of the shoe adjustment (see section on Bendix brakes, Vol. I).

Slack off centraliser nut on the outside of the backing plate and turn shoe adjuster in a clockwise direction as far as it will go. Tighten centraliser nut and slack off shoe adjuster until wheel is just free.

When shoes need relining, the brake shoes should be removed and returned to the makers, when replacement shoes will be supplied. The desired clearance of shoe in drum is 0·008 in.

FRONT SUSPENSION OF LANCHESTER 14-H.P. DE LUXE

The André-Girling independent front-wheel suspension employs a system of linked arms which ensures that each front wheel follows independently the road inequalities. It is possible to drive over uneven road surfaces with the maximum of riding comfort and road-holding.

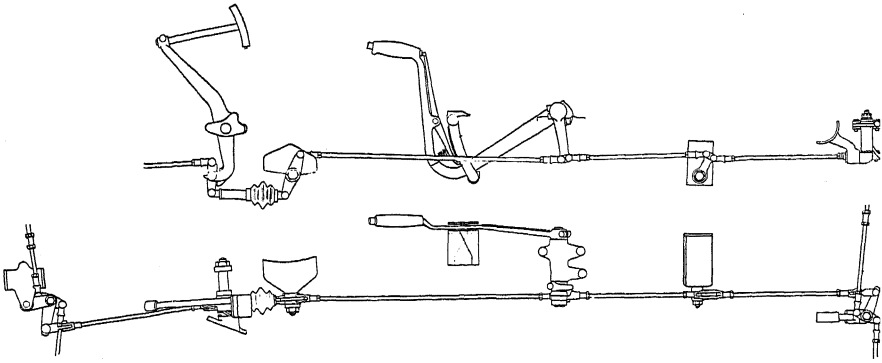


Fig. 10.—LAYOUT OF GIRLING BRAKING SYSTEM ON LANCHESTER 10-H.P., 18-H.P. (1935 ONWARDS), 11-H.P., AND 14-H.P. ROADRIDER

To remove the large oil springs, the front of the car should be jacked up and supports placed under the frame members. Remove the wheels and place a jack under one of the transverse links in its extended position. The jack should be placed near the inner end of the link and the centre bolt removed, allowing the weight to be taken by the jack until the springs can be removed.

Inspect the bolts holding the silentbloc bushes and the spherical joints at the bottom of the pedestal. These bolts should all be tight and not be allowed to float in the bush.

The toe-in of the front wheels should be $\frac{1}{8}$ in. minimum to $\frac{3}{16}$ in. maximum, and it is imperative that these figures are strictly adhered to. Adjustment of toe-in is as follows :

Slacken locknuts at the outer ends of both track rods and remove ball pins from stub-axle steering arms.

Set wheels dead parallel. This may be done by measuring from frame to inner edge of wheel rim.

Adjust both rods until the combined toe-in is $\frac{1}{8}$ in. and not greater than $\frac{3}{16}$ in. and replace ball pins and split pins, and tighten locknuts.

When this adjustment is made, it is important to check the position of the steering-pivot lever. With the front wheels in central position, the lever should be dead parallel with the wheels.

Camber

Desired angle is $1\frac{1}{2}°$. If the wear on either of the front tyres is found to be uneven, or wearing more on the outside than on the inside, a careful check should be made of the camber of the wheel concerned. This is adjustable by means of the short transverse link at the top of the pedestal. Before removing either of the bolts at the ends of this link for adjustment, the front of the frame should be supported by a jack. One bolt can then

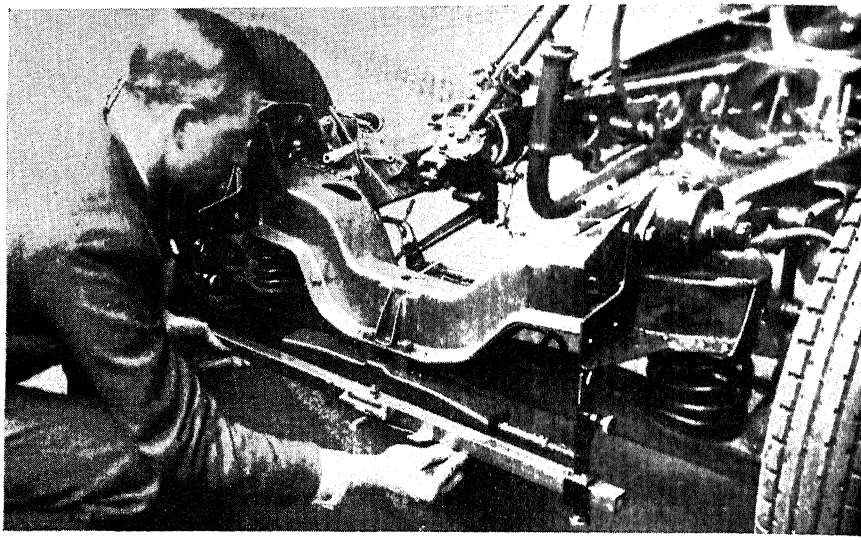


Fig. 11.—TO CHECK CAMBER

First ascertain whether car is perfectly level. The picture shows typical spirit-level gauge with two sliding arms. Adjust pressure in tyres until spirit-level reads centrally.

be removed and the link adjusted to suit. It is important that the frame remains in its normal unloaded position, and it should not, therefore, be lifted when jacking up.

Both settings for track and camber are given with the cars in an unloaded position.

CAM AND LEVER STEERING

The cam-and-lever type steering as fitted to 1933–5 10-h.p. and 1933–4 18-h.p. models is simple in construction and requires little attention.

The cam and mainshaft are mounted on ball bearings which take the thrust from the rocker shaft, and shims are introduced under each end cover so that the cam is mounted centrally in the box. If the gear is dismantled for cleaning or inspection a careful note of the number of shims at each end should be made. On reassembling this shaft should "spin" with the fingers, but there should be absolutely no end play. If necessary to remove shims, remove them equally from both ends if possible.

The Rocker Shaft

The motion of the steering wheel is transmitted to the road wheels through the cam, and the roller fitted into the rocker shaft lever, and in

time, wear (as shown by "lost motion" between the steering wheel and the drop arm) may possibly become apparent. This may be rectified by removing one or more of the shims underneath the side cover plate covering the rocker shaft lever. If too many shims are removed the gear will become stiff on full lock and this must not be permitted.

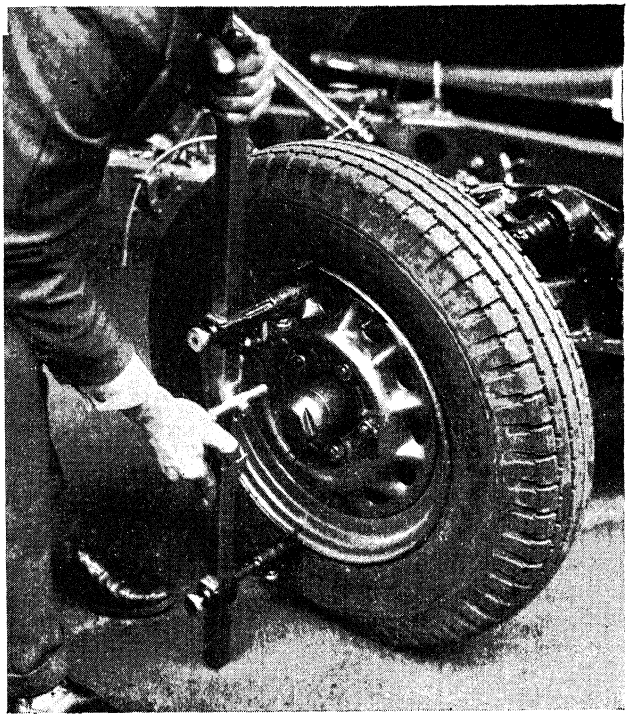


Fig. 12.—TOOL IN USE TO CHECK CAMBER ANGLE

The roller runs in a hardened steel bush, and these two parts must always be a very close fit, being only just sufficiently free to revolve. In some models the roller is replaced by a conical pin which does not revolve.

All adjustments to the steering gear should be carried out with the drag link disconnected.

Removal of the Drop Arm

The drop arm is attached to the rocker shaft by means of a splined taper and secured by a slotted nut. Lugs are provided on the drop arm in order to facilitate removal by means of a drawer, but if this means is not available and it is necessary to use a hammer, *the side cover plate must be removed first,* and the shaft should be driven through the drop arm, so that the reaction from the blow is taken on the main casing instead of on the hardened steel cam and roller.

Replacing the Drop Arm

When replacing the drop arm, care must be taken to refit it to the correct spline to give an equal lock. If the parts were not marked before dismantling, attach the drop arm to the drag link by its ball pin, and after

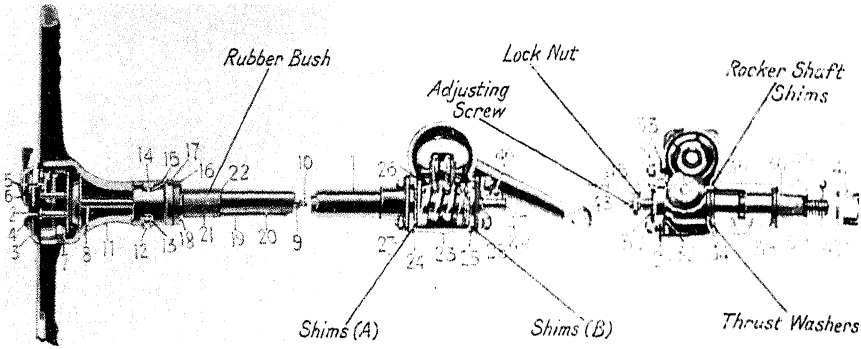


Fig. 13.—STEERING GEAR, 14-H.P. LANCHESTER DE LUXE

The shims (*A*) are for cam-bearing adjustment. Shims (*B*) should not be interfered with. The adjusting screw is for adjusting end play of rocker shaft, while the rocker-shaft shims, situated between the thrust washers, are for taking up slack at drop arm.

placing the road wheels in the "straight ahead" position, turn the steering wheel as far as it will go on the left lock, then bring it back three-sevenths of its full motion and mount the drop arm on the spindle in this position, taking care to ensure that the slotted nut is tightened right home and the nut securely split pinned. The front axle should then be jacked up and a test made to ensure that there is full lock on both sides and that the stub axles come properly up against the stops on the front axle beam.

THE DOUBLE-ROLLER TYPE STEERING AS FITTED TO LANCHESTER 14-H.P. DE LUXE

Cam Bearing Adjustment

Referring to Fig. 13, it will be seen that there are a number of shims (*A*) between the steering-box casting and the column support. The end play on the cam between the bearings can thus be removed by taking out one or more of these shims. This allows the thrust cone carried by the column support to enter farther into the steering box, and thus come closer to the cam.

Between the steering box and the bottom cover there are similar shims (*B*), but it is not necessary to disturb these, as they are, for the purpose of centring the cam, relative to the rocker shaft, and are correctly set upon assembly.

Adjustment of End Play of Rocker Shaft

Loosen locknut on back of cover plate and tighten adjusting screw until end play is removed. Do not forget to tighten locknut after adjustment.

The correct method of ascertaining the elimination of end play is to turn steering wheel on either full lock and turn back about one-eighth of a turn. The rocker shaft should rotate freely without any end play when the drop arm is held firmly at steering-box nose.

Adjustment of Engagement between Roller and Cam

Disconnect drag link and turn steering wheel to mid position. Shake drop arm to determine amount of slack, and if this is more than $\frac{1}{32}$ in., adjustment is necessary.

It will be seen in Fig. 13 that there are a number of shims between the thrust washers behind the rocker shaft. By removing one or more of these shims, the rocker shaft and roller will enter farther into the box, thus making close contact with the cam.

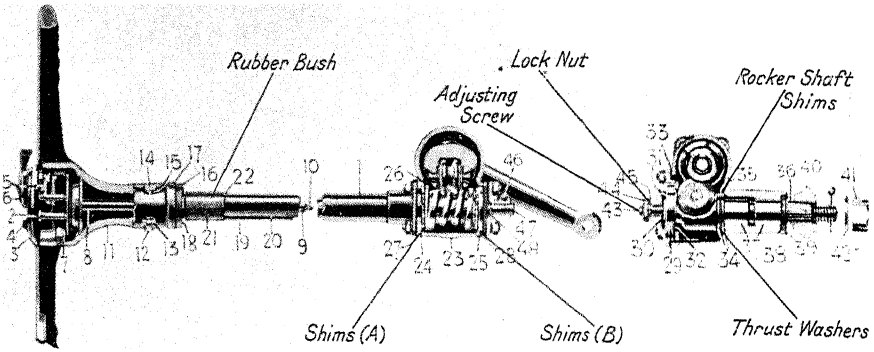


Fig. 13.—STEERING GEAR, 14-H.P. LANCHESTER DE LUXE

The shims (*A*) are for cam-bearing adjustment. Shims (*B*) should not be interfered with. The adjusting screw is for adjusting end play of rocker shaft, while the rocker-shaft shims, situated between the thrust washers, are for taking up slack at drop arm.

placing the road wheels in the " straight ahead " position, turn the steering wheel as far as it will go on the left lock, then bring it back three-sevenths of its full motion and mount the drop arm on the spindle in this position, taking care to ensure that the slotted nut is tightened right home and the nut securely split pinned. The front axle should then be jacked up and a test made to ensure that there is full lock on both sides and that the stub axles come properly up against the stops on the front axle beam.

THE DOUBLE-ROLLER TYPE STEERING AS FITTED TO LANCHESTER 14-H.P. DE LUXE

Cam Bearing Adjustment

Referring to Fig. 13, it will be seen that there are a number of shims (*A*) between the steering-box casting and the column support. The end play on the cam between the bearings can thus be removed by taking out one or more of these shims. This allows the thrust cone carried by the column support to enter farther into the steering box, and thus come closer to the cam.

Between the steering box and the bottom cover there are similar shims (*B*), but it is not necessary to disturb these, as they are, for the purpose of centring the cam, relative to the rocker shaft, and are correctly set upon assembly.

Adjustment of End Play of Rocker Shaft

Loosen locknut on back of cover plate and tighten adjusting screw until end play is removed. Do not forget to tighten locknut after adjustment.

The correct method of ascertaining the elimination of end play is to turn steering wheel on either full lock and turn back about one-eighth of a turn. The rocker shaft should rotate freely without any end play when the drop arm is held firmly at steering-box nose.

Adjustment of Engagement between Roller and Cam

Disconnect drag link and turn steering wheel to mid position. Shake drop arm to determine amount of slack, and if this is more than $\frac{1}{32}$ in., adjustment is necessary.

It will be seen in Fig. 13 that there are a number of shims between the thrust washers behind the rocker shaft. By removing one or more of these shims, the rocker shaft and roller will enter farther into the box, thus making close contact with the cam.

SERVICING VAUXHALL 10-H.P. AND 25-H.P. INDEPENDENT SUSPENSION SYSTEMS

By K. SYLVESTER

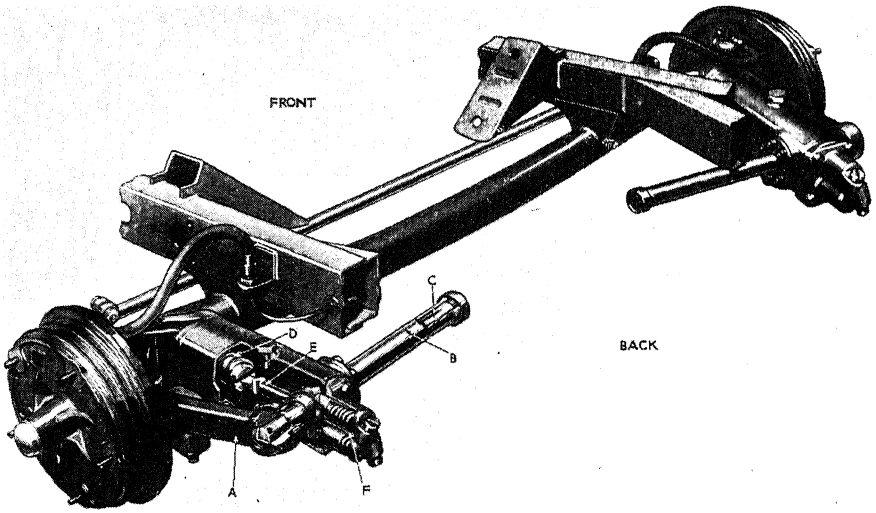


Fig. 1.—CUT-AWAY VIEW OF 10-H.P. MODEL FRONT SUSPENSION UNIT

IN order to be able to diagnose faults correctly it is essential for the mechanic to have a clear idea as to "the why and the wherefore" of the system which is employed on the Vauxhall 10-h.p. and 25-h.p. models.

Why Independent Suspension ?

The primary aim of the designers was to obtain a very soft ride without the consequent disadvantages of instability and inaccurate steering. All the difficulties with steering geometry which are encountered in a normal suspension, due to the fact that the steering connections are partly mounted on the sprung chassis and partly on the unsprung front axle assembly, are overcome. In the case of the Vauxhall the whole of the steering mechanism is mounted solely on the chassis, and no unwanted relative movement between the connections can therefore take place.

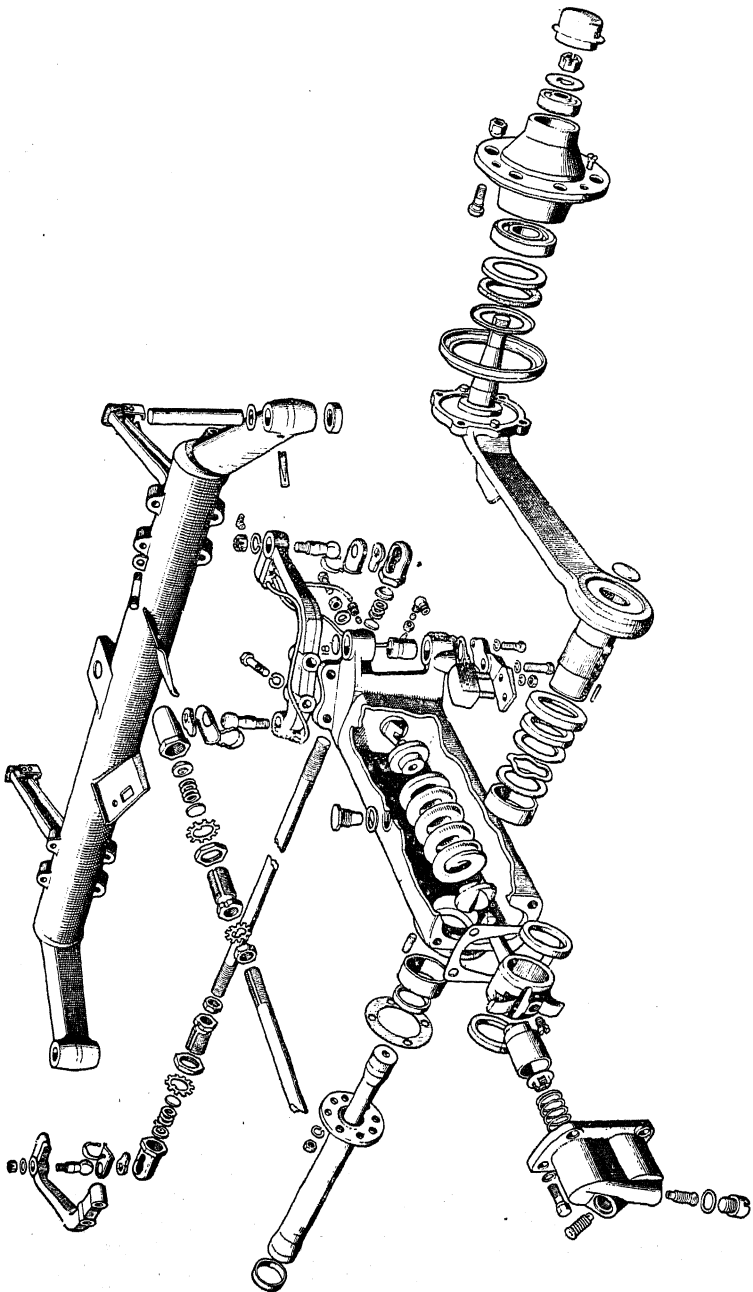


Fig. 2.—FRONT AXLE BEAM AND INDEPENDENT SUSPENSION DETAILS, 25-H.P. MODEL

In order to obtain the very soft springing which was aimed at, some means had to be found of stiffening up the suspension for large deflections, otherwise the total movement would be excessive. The apparently obvious method of using a very soft spring and then incorporating buffers to limit its travel would be a poor engineering job, and a more scientific method has been developed. Instead of using a soft spring and limiting its movement with buffers, a hard spring (torsion bar) has been used, coupled with a compensating toggle spring so arranged as to assist the wheels to deflect the torsion bar throughout the range covered by normal deflections. However, the effectiveness of this compensating spring diminishes with deflection and thus a progressive springing is obtained.

The result is a system of suspension which is extremely soft and flexible on the "sweet spot," but which progressively stiffens up as the deflection increases; in other words, a soft suspension for normal driving which tends to stiffen up considerably at higher speeds—when deflections are greater—and which has a resistance to roll which could not possibly be provided with a normal soft suspension.

Explanation of System

The following explanation should be read in conjunction with Fig. 1. The wheel is carried on the wheel carrier-arm (*A*). The other end of the wheel carrier-arm is supported by means of a splined sleeve mounted on needle roller bearings in a steel housing, which is hinged by means of a pivot pin to a cross-member which takes the place of the front axle; this cross-member is, of course, rigidly bolted to the chassis.

External splines at one end of the torsion bar (*C*) engage with internal splines in the sleeve, which is integral with the rear end of the wheel carrier-arm. The other end of the torsion bar is splined to the torsion tube (*B*), the flanged end of which is bolted to the suspension housing.

Dealing now with that part of the suspension which has already been described, and ignoring the other mechanism, it can be seen that upward movement of the wheel will turn the wheel carrier-arm (*A*) in a clockwise direction. As the wheel carrier-arm is attached to the torsion bar this will also be twisted in a clockwise direction, and this twist must be taken up by the bar and tube. The reason for using a bar and a tube is to obtain a great length of "spring" in as compact a space as possible. As so far described this could be used as a normal independent suspension, but in order to obtain the progressive springing which is essential to a comfortable *and* stable ride the compensating spring (*D*) is incorporated. The toggle arm (*E*) is attached by means of a grub screw to the outer diameter of the sleeve previously mentioned, and the knife edge is loaded by a short but very stiff coil spring (*D*) under compression. On the opposite end of the toggle are feet which engage with the pistons of the double-acting shock absorber (*F*), which is bolted to the rear end of the housing.

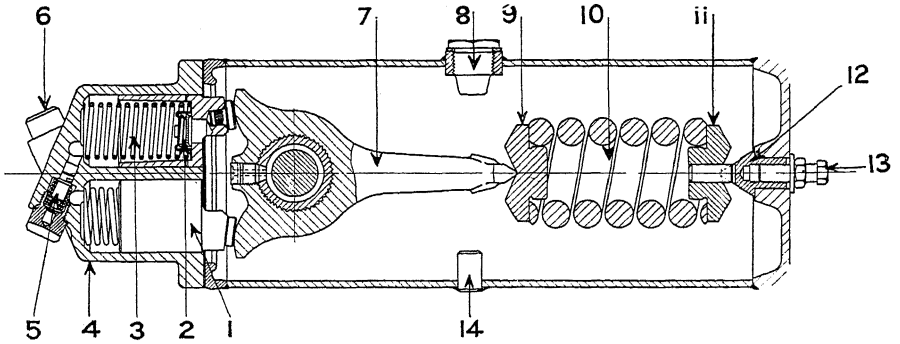


Fig. 3.—SECTIONED VIEW OF FRONT SUSPENSION UNIT

1. Shock absorber piston.
2. Inlet valve.
3. Contact spring.
4. Shock absorber housing.
5. Metering valve (controlling upward movement of wheel carrier arm).
6. Rebound valve retaining cap.
7. Compensating spring—control lever.
8. Filler plug and upper stop.
9. Compensating spring rear seat.
10. Compensating spring.
11. Compensating spring front seat.
12. Knife edge.
13. Lock stop.
14. Lower control lever stop.

Referring to the drawing, Fig. 3, it will be seen that movement of the wheel carrier-arm moves the compensating lever, the feet of which bear against hardened-steel pads on the shock-absorber pistons and thus cause the pistons to move. The pistons are pushed up into the cylinders by these feet and are returned by the coil springs (3). The fluid is always passed from one cylinder to the other, and in so doing it is forced through the metering valves (5) and (6). These valves consist of a "slow leak" hole through which the fluid normally passes, and a spring-loaded valve through which excess fluid passes under severe deflection.

Maintenance Attention

As the whole of the mechanism is enclosed in an oil bath, the only attention required is to keep the oil bath full of shock-absorber oil. It is most important to use only an approved shock-absorber oil, as ordinary lubricating oil would upset the calibration of the suspension entirely.

Setting of Torsion Bars

Torsion bars have to be set so that the car will be riding on the "sweet spot" when carrying a normal load, and for this purpose an adjustment in the form of a vernier is provided.

The first thing to bear in mind with one of these torsion bars is that the minutest scratch or dent in the bar will almost certainly be a point of fatigue fracture sometime during the life of the bar. When handling these bars, therefore, it is essential to be extremely careful not to bump them in any way. The bar itself must not even be touched by hand, as perspiration is sufficient to set up oxidation of the bar, which will weaken it considerably.

To Remove Tube and Bar Assembly for Resetting

Obtain a receptacle to receive the shock-absorber oil, which may be drained by taking out the lower setscrews attaching the shock-absorber unit to the rear face of the housing. Raise the front of the car by means of a jack until the wheels hang clear of the ground. Remove the nuts and washers securing the flange of the torsion tube to the housing. In order to remove the tube and bar assembly for resetting, the position of the wheel carrier-arm at which there is no torsion must be found. To find this position, lower the car slowly until the position is obtained when the torsion bar and tube is loose.

The best way to do this is for one man to lower the car while another watches the flange on the studs *with a good light*. The moment the tube passes from torsion in one direction to torsion in the other, i.e. the free point, the flange can *just* be seen to move on the studs. In this position the torsion tube can be pulled out quite easily. *DO NOT USE FORCE*. If it will not come out easily, it indicates that the free point has not been found.

The splines on the bar and the holes in the flange are so arranged that a vernier coupling is obtained ; turning the tube round one hole will actually have the effect of moving the position of the wheel carrier-arm slightly less than 1°.

Setting the Bar and Tube

The bar and tube must be turned in the direction in which the wheel carrier arm is to be moved in order to produce the desired result. In other words, if the left-hand side of the car is to be raised, the wheel carrier-arm must be turned in a clockwise direction as viewed from the torsion-tube side—that is, the side from which the man on the job will view it—and the torsion tube must therefore be turned in a clockwise direction. To raise this side of the car, therefore, remove the torsion tube, turn it round nearly one complete stud hole, engage the splines and then raise the car *slightly* so that the flange can be pushed over the studs.

Correct Riding Height of Car

Lower the car slightly until some weight is taken by the wheels and then replace and tighten up the flange nuts. It is most important to set these torsion bars so that the car rides at the correct height. In the case of the 25-h.p. model, this is when the dimension as shown in Fig. 4 is 4 in. plus or minus $\frac{1}{8}$ in. with two people, or the equivalent ballast, in the front seats. On the 10-h.p. model the dimension is taken vertically from the lower edge of the brake-flange plate to the head of the front bolt attaching the steering arm to the steering knuckle. This dimension should be $1\frac{1}{4}$ in. plus or minus $\frac{5}{64}$ in. with two people in the front seats.

It is most important to have these dimensions correct, as otherwise

the car will not normally be riding on the "sweet spot" and the suspension will therefore be hard.

To Replace a Broken Torsion Bar

If the bar of the assembly to be replaced has broken, the tube should be withdrawn and the remaining portion of the bar extracted, if necessary, by removing the expansion plug in the wheel carrier-arm and tapping the shaft out gently, using a brass drift, afterwards fitting a new expansion plug. The weight of the car, in the absence of resistance from the torsion members due to the breakage, will have moved the wheel to its extreme lift position so that the toggle butts against the combined stop and filler plug.

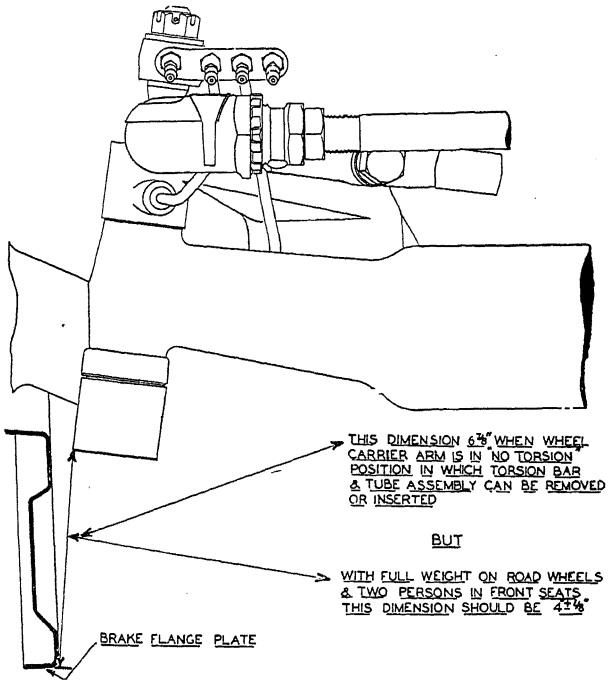


Fig. 4.—How dimensions are measured when checking for height adjustment (25-h.p. model)

The wheel must, therefore, be pushed down with the aid of an assistant so that the toggle is brought over "dead centre" against the pressure of the compensating spring, when it will rest on the lower stop of the housing. The new torsion bar and tube assembly can then be fitted in the normal way.

To Dismantle Suspension Unit

The following description applies to the 25-h.p. model and should be read in conjunction with Fig. 2. The system used on the 10-h.p. model is almost identical, and a separate description is not therefore warranted.

To dismantle the suspension unit, it must be removed from the chassis. It is, however, advisable to remove the torsion bar and tube assembly first, as the weight of the car can then be used to bring the wheel carrier-

arm to the " no torsion " position in the normal way so that the tube and shaft can be withdrawn.

It is also advisable to remove the brake assembly, which is attached by four setscrews to the wheel carrier-arm. The assembly can then be laid on one side, and in this way there is no need to disturb the hydraulic braking system.

The front suspension unit can now be detached from the kingpin in the normal way.

Remove the shock-absorber assembly by taking out the four setscrews which hold it in position. Remove the grub-screw which secures the control lever to the carrier-arm journal after clearing the punch marks which lock it in position.

Press the wheel carrier-arm out of the housing, taking great care to catch the needle rollers, which will probably fall out during this operation.

Draw out the control lever with its side washers and then withdraw the remaining parts in the following order :

Knife-edge seat.

Spring.

Lower knife-edge seat.

The inner knife edge should not be removed unless it is absolutely essential, as it has to be replaced exactly parallel with the axis of the wheel carrier-arm, and it is by no means easy to do this with the necessary accuracy. Remove the oil-seal retainer from the carrier bearing outer end, and press out the outer races. This completes the dismantling of the unit.

To Reassemble Suspension Unit

Press in the needle roller outer races. Press a new oil seal into the counterbore of the housing and crimp the lip of the cap into the groove on the outside of the boss of the housing. If the inner knife edge has been removed, this must now be pressed into position, and it is absolutely essential that it should be parallel with the carrier-arm journal to within a quarter of a degree. Now place the housing vertically in a vice and lower the following parts carefully into position :

Front knife-edge seat.

Spring.

Rear knife-edge seat.

Allow these parts to rest on the bottom side of the housing (away from the filler plug), place the control lever and spacers into the housing, and check the side clearance. This should be within the limits of ·002 in. to ·007 in., and in order to obtain the requisite clearance, spacers of varying thicknesses can be obtained from the manufacturers. The part number of the normal spacer is 1034054, the thick spacer is 1034053, and the thin spacer is 1034055.

Having placed the control lever into the housing with the thickened

spline towards the filler-plug side, lay the 43 needle rollers in the outer race, keeping them in position by means of thick grease.

Enter the wheel carrier-arm so that the thickened spline on the journal lines up with the thickened spline in the control lever. Some difficulty will probably be experienced in entering the arm without disturbing any of the needle rollers, but this operation is quite possible with patience.

Press the carrier-arm into position, secure it with the grub-screw, and lock the screw by means of punch marks. Drop the 41 needle rollers of the opposite journal into position, followed by the spacer, and refit the shock absorber. The unit is now ready for refitting to the chassis, after which the torsion bar and tube assembly can be fitted and adjusted for correct height as previously described.

The above instructions apply also to the 10-h.p. model, except that there are 63 needle rollers in the outer wheel carrier-arm bearing and 52 in the inner bearing. The part numbers of the control-lever spacers are as follows :

Outer spacer . . .	1037054
Inner spacer—thin . .	1037266
Inner spacer—thick . .	1037267

Front-wheel Alignment—Important

The front-wheel alignment of the Vauxhall 10-h.p. and 25-h.p. models differs from standard practice in that the wheels must be set parallel (no toe-in) when in the straight-ahead position. When carrying out this adjustment, two people, or their equivalent in ballast, must be in the front seats of the car. as the setting varies considerably with load.

Springing too Hard

The most likely cause of this is that the torsion bars are so set that the car is not normally riding on the " sweet spot." It must be appreciated that the springing provided by the torsion bar and tube is very stiff, and unless this is correctly modified by the compensating spring, the ride is bound to be hard. All that is necessary is to check up the measurements as given previously, and to reset the torsion bars if necessary.

Another possibility is that the housings have been allowed to run short of fluid, so that the shock absorbers may work on air for the first part of the stroke and then suddenly come up against the fluid. This causes springing that is harsh rather than hard.

It should also be ascertained that the correct fluid is used. Attempts are sometimes made to stiffen up the suspension by adding a small quantity of engine oil, but this practice is extremely bad, and if the fluid is suspected, it should be drained out and the housings refilled with an approved brand.

Springing too Soft

In the case of the 25-h.p. model, this may quite possibly be an impression rather than a fact. Drivers coming off a car of normal suspension on to the Vauxhall " 25 " are inclined to have a feeling of insecurity during the first few hundred miles, due to its extreme softness. However, if they can be persuaded to retain the suspension as it is for some five hundred miles, they usually become accustomed to this false feeling of insecurity. It is most undesirable to stiffen up the springing, as its whole beauty lies in the softness and absence of pitch. However, if the springing really is soft, the following points should be checked over :

The seating of the inlet valve which is located inside the piston : it is possible that a particle of grit has got on the seating of this valve and so prevents it functioning correctly.

A broken shock-absorber spring will, of course, put that particular piston out of action, but this is usually accompanied by noise, and can be detected in that way. The only other possibility is that a piston may be stuck in its cylinder, and in this case the remedy is obvious.

If all the above points are found to be in order, then the springing is as designed by the manufacturers and should not be altered.

There is, however, a method of stiffening up which, although not recommended by the manufacturers, does function tolerably well.

In the case of the 25-h.p. model, the rebound valve is of a more severe nature than that of the bump valve. If, therefore, a rebound valve is inserted in place of the bump valve, it will have the effect of stiffening up the suspension considerably. The rebound valve can be distinguished from the bump valve by the fact that the spring of the former is cadmium-plated, and that of the latter copper-plated. The bump valve is that which is retained by the lower plug, and the rebound is retained by the upper plug.

The above remarks apply to the 10-h.p. model also, with the exception of the distinguishing features of the valves : the spring of the rebound valve is stronger than that of the bump, and the larger gauge of the wire can easily be seen on comparing the two valves.

REPAIR AND OVERHAUL OF FORD CARS

REAR AXLES, FRONT AXLES, BRAKES, STEERING AND CHASSIS

By J. W. SANDERMAN, A.M.I.A.E.

REAR AXLES

Adjustment of Drive-pinion Bearings

ONE of the most important points in overhaul of rear axles is the adjustment of the drive-pinion bearings. All these bearings are assembled with an adjustment giving a pre-loading.

A service tool is available with which this pre-loading may be measured, and it is advisable to use some such instrument to maintain the adjustment on the different models, as follows :

On 24-h.p. and 14·9-h.p. passenger cars and early V-8 cars, where the drive pinion has no pilot bearing, the pre-load should be between 15 lb./in. and 20 lb./in.

On all other V-8 cars, where the drive pinion is provided with a pilot bearing, the pre-load should be between 12 lb./in. and 17 lb./in.

The drive-pinion bearing pre-load on the trucks should be between 12 lb./in. and 16 lb./in., while the pre-loading on 8-h.p. and 10-h.p. vehicles should be between 4 lb./in. and 6 lb./in.

Drive-pinion bearings should always be a good tight fit in their housings, and when assembling a new bearing it should be shrunk into place by heating the axle casing, preferably in hot oil, until the bearing can be lightly pressed into its housing.

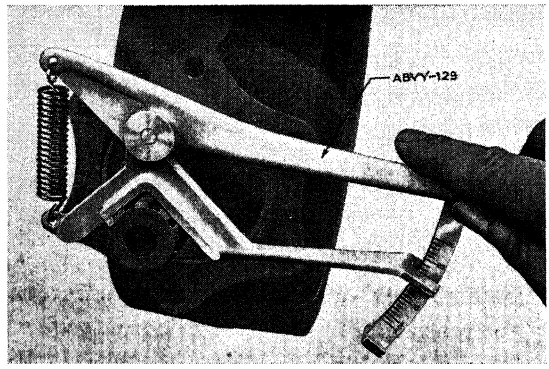


Fig. 1.—GAUGE FOR SETTING PRE-LOAD OF DRIVE PINION BEARINGS

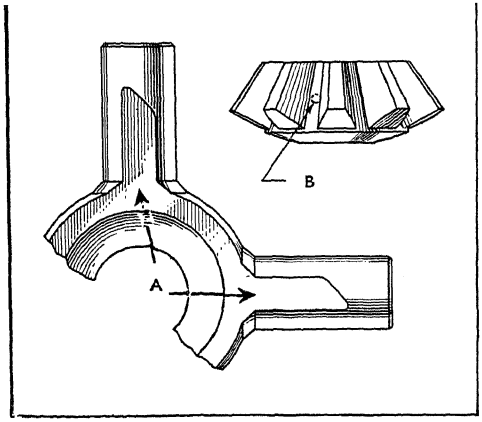


Fig. 2.—TRUCK DIFFERENTIAL SPIDER AND PINIONS

A. Lubrication flats on spider arms.

B. Oil hole drilled here when spider has no lubrication flats.

Replacing Differential Spider and Pinions

A particular point to note is the differential spider and pinions. Should it be necessary to replace these parts, the spider fitted may or may not have flats machined on each arm. These flats are for lubrication purposes and it will be found that the pinions fitted are not provided with oil holes. Should the spider have no flats on the arms the pinions fitted will have oil holes drilled between the teeth to permit lubrication, and in no circumstances should undrilled pinions be used together with spiders which do not have the lubrication flats on the arms.

End Float in Axle Half-shafts

On 8-h.p. and 10-h.p. models the thrust on the axle half-shafts is taken on a pad mounted on the differential spider shaft and a thrust face on the end of each axle half-shaft.

Should these faces become scored through faulty lubrication or should too much wear develop, this will permit excessive end float in the shafts, when the only remedy is replacement of the affected parts.

Crown Wheel and Pinion

To ensure maximum efficiency and quietness of operation, crown wheels and pinions are supplied in matched pairs and should always be replaced in this manner. It is false economy to try to replace one of these parts, however good the other may appear, as apart from any wear which has taken place, the tooth surfaces have bedded in running to the other original part and cannot be expected satisfactorily to mate with an odd new part, with the result that when the new part has bedded down excessive backlash may result, together with bad tooth contact, which can only result in rapid wear.

Reassembling 6-wheeler Intermediate Torque Tubes

In reassembling the intermediate torque tube between the two driving axles of six-wheeled vehicles, care must be taken to see that the universal joint caps and torque tube are correctly positioned to avoid damage in operation.

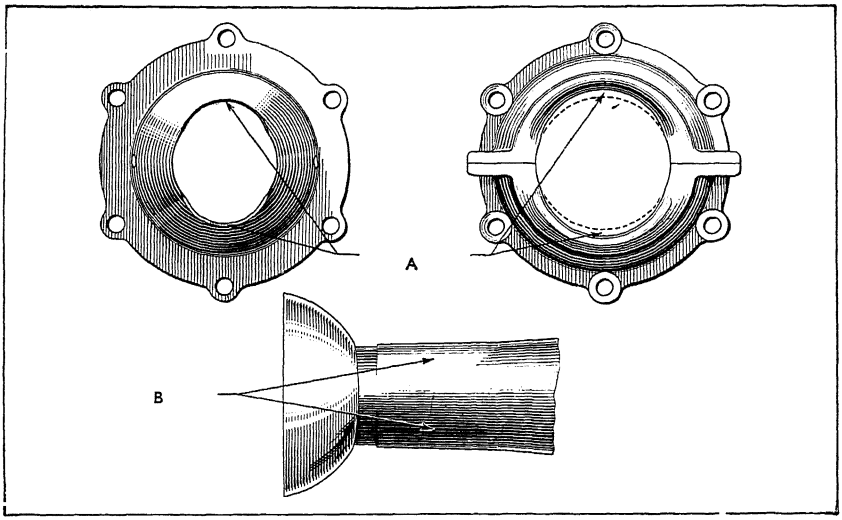


Fig. 3.—CORRECT ASSEMBLY OF SIX-WHEELER INTERMEDIATE TORQUE TUBE

A. Clearance for articulation in universal joint cover.
B. Showing points which engage in cover clearances.

It will be noted that the caps have the hole through which projects the torque tube elongated to permit maximum articulation, and these must be assembled with the elongations at the top and bottom. The early torque tubes had two clearance flats at the point where it entered the cap, which must also be assembled top and bottom. Later torque tubes are elliptical at this point and must be assembled with the lesser axis vertical.

Use of Extreme Pressure Lubricants

In view of the heavy load imposed on rear axles to-day, due to increased engine power and, in the case of commercial vehicles, increased pay loads, lubrication has become a much greater problem, and it is advisable to use only an extreme pressure lubricant in these components. The very slight extra cost is more than offset by the greater margin of lubrication safety these oils provide, as the breakdown of the oil film under pressure is approximately twice as high as an ordinary gear oil.

There are several types of extreme pressure lubricants on the market, some of which are rather unstable in service and tend to precipitate, while it is not possible to mix these with other gear oils or extreme pressure lubricants without the danger of undesirable chemical action.

It is also necessary to drain and flush out these oils at intervals so that their use is attended with some additional bother in regular maintenance.

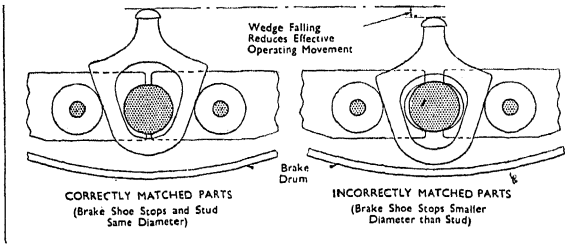


Fig. 4.—CORRECT AND INCORRECT FITTING OF BRAKE SHOES AND OPERATING WEDGES

If, however, the extreme pressure lubricants approved by Ford Motor Company are used, the above mentioned characteristics will be avoided, as these may be used in exactly the same manner as the previous ordinary gear oils.

These extreme pressure lubricants may be mixed with each other or any ordinary gear oil, although it is obvious that to obtain the best from any lubricant it is advisable to decide on one type and not to change.

These approved extreme pressure lubricants may also be used with safety in gearboxes, whether plain or synchromesh. This is a useful characteristic, as it saves the necessity of stocking an unnecessary number of oil types to ensure correct lubrication.

FRONT AXLES

Renewing Stub-axle Bushes

Few special precautions are necessary in overhauling front axles, but one of the most important is the renewing of stub-axle bushes.

These bushes being of the split type should not be reamed after replacement, but should be burnished broached, so that they are expanded securely into position and the necessary hard working-surface is formed.

Radius Rods

Particular attention should also be given to the front-axle radius rods, where these are fitted, to ensure these have not been strained, as any slight bend will throw the whole front axle out of true alignment. Should either of the radius rods be badly bent, straightening is not advisable, as in this case the metal will have undoubtedly stretched and even when correctly straightened may be slightly longer than originally, with consequent misalignment.

The rear end of these radius rods is carried in a rubber-bushed socket, and should any doubt exist as to the resiliency of the rubber ball joint this should be renewed. An unsatisfactory ball rubber will give rise to many baffling troubles, such as unsatisfactory steering, brake judder, etc.

Front-wheel Alignment Settings

Important points in front-wheel alignment are castor, camber, and toe-in ; these settings varying with different models.

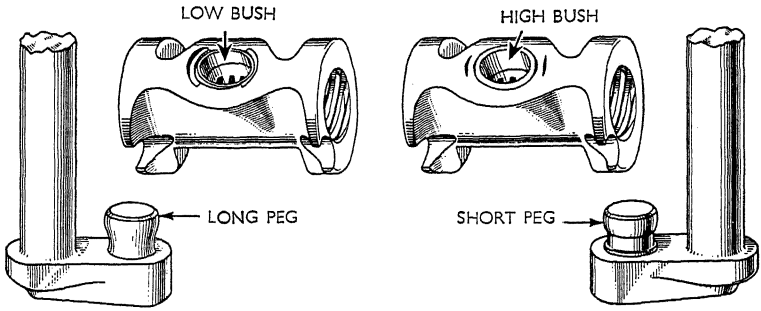


Fig. 5.—STEERING ARM AND NUT COMBINATION

The larger passenger models have a castor of 9°, a camber of 2° on earlier models or 1° on later models, and a toe-in of $\frac{3}{32}$ in.

The 8-h.p. and 10-h.p. vehicles have a castor of 8°, a camber of 2°, and a toe-in between $\frac{1}{16}$ in. and $\frac{1}{8}$ in.

Trucks have a castor of 5°, a camber of 2° in the case of early models and $\frac{3}{4}$° on later models, with a toe-in of $\frac{3}{32}$ in. on early models and no toe-in on later vehicles. The exception to these figures is the 25-cwt. forward vehicles control, where the castor is 7°, the camber 1° 7′, with a toe-in of $\frac{1}{16}$ in.

Maximum variation between the wheels should not exceed $\frac{1}{2}$° on castor and $\frac{1}{4}$° on camber.

BRAKES AND STEERING

Brake Shoe Replacement

There are very few special precautions necessary in the overhaul of these components, but when installing new or reconditioned brake shoes on 8-h.p. and 10-h.p. models see that these are of the correct type and seat correctly on the operating wedge-locating stud.

Two diameters of stud have been used, and if shoes with a different locating radius are installed, either they will drop from a concentric position or they will not be able to fully close, so allowing the wedge to drop and either score the drum when the brakes are operated or prevent full operation by coming too soon to the limit of its travel. (This applies only to wedge-operated brakes fitted prior to the current Girling system.)

In all cases where brakes are wedge operated it should be ascertained after overhaul that accumulated wear in various working parts does not permit the wedge to " bottom " on the stud before maximum pressure is applied to the drum.

Where brakes require relining it is not to-day economical to replace the linings, but far more satisfactory to take advantage of Ford Motor

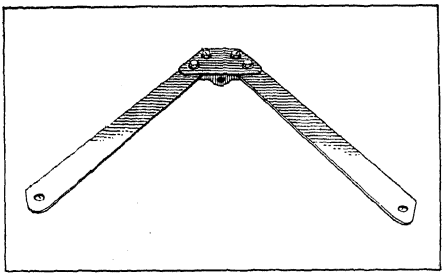


Fig. 6.—SIX-WHEELER BRACE SPRINGS. The long arm goes towards the rear.

Company's exchange scheme, where not only are shoes relined, but all other parts, such as rollers, pins, etc., replaced as required.

Assembling Steering Nut

A precaution to observe in the 8-h.p. and 10-h.p. steering gear is the assembly of the steering nut. Two types of steering shaft have been used, one having the peg which engages with the nut longer than the other, the bush in the nut used with the long peg being sunk deeper in the nut than previously.

Although it will be quite satisfactory to use the nut having the "high" bush with the shaft having the long peg, under no circumstances must the shaft with the short peg be used with a nut having a "low" bush.

CHASSIS

Replacing Complete Chassis Frame

Should it at any time become necessary to replace a complete chassis frame of 8-h.p. or 10-h.p. models, it will be found that these are rigidly attached to the body by rivets and spot welding.

Rivets should wherever possible be cut out from inside the chassis member and points of spot welding carefully broken so as not to unduly damage the body attachment flange.

It is not advised that re-riveting be attempted upon replacement, as however good the original holes may appear some distortion is sure to be present. It will be found preferable to use bright steel machined B.S.F. bolts with plain and spring washers for this purpose.

If body is damaged, the base should first be straightened up so that the securing holes line up with the chassis frame holes without undue strain. Temporarily locate the body in position with bolts, one at each end of each chassis side member and at the front of each rear wheel arch.

The remaining holes should now be drilled "dead size" $\frac{5}{16}$ in. and $\frac{1}{4}$ in. as may be indicated, so that the bolts are a light drive fit, each bolt being fitted with the head on the outside and a bright steel plain washer between the head and body flange; a nut with spring washer being inside the chassis frame.

Drill and install one bolt at a time to prevent minor body misalignment and, in the case of four-door models, position, drill, and bolt the centre pillar last of all.

Reassembling Springs

Particular care must be taken when reassembling springs to chassis cross-members that the square head of the tie bolt is properly seated in the square hole cut in the cross-member to receive it.

Failure to observe this and also to maintain U-bolts fully tightened will give rise to continual hammering, which may eventually fracture the cross-member.

A point to watch in assembling the rear-axle brace springs on six-wheeled vehicles is that the longer of each pair of spring arms is assembled towards the rearmost axle.

When these brace springs are correctly assembled and the vehicle is unloaded they should have a slight curve or camber and will have to be forced into position. This is quite in order, as under load they will straighten out to take a load in tension. Under no circumstances should these springs be flat when the vehicle is unloaded, otherwise when under load undue stress will be thrown on various components.

Assembling Steering Gear to Frame

In assembling the steering gear to the frame take care to avoid placing undue stress on this component by first positioning the steering on the chassis member with the bolts just finger tight, then secure the column support bracket to the dash sufficiently tight to correctly position the column.

All points round the steering-box bracket flange should be checked with a feeler gauge between the bracket and side-member face, and where gaps occur the bolt must be removed and the space taken up by means of suitable shims, after which final tightening can be carried out.

SERVICING PACKARD SIX, EIGHT, AND SUPER EIGHT, 1937-9

REAR AXLE BRAKES, SUSPENSION, STEERING, ETC.

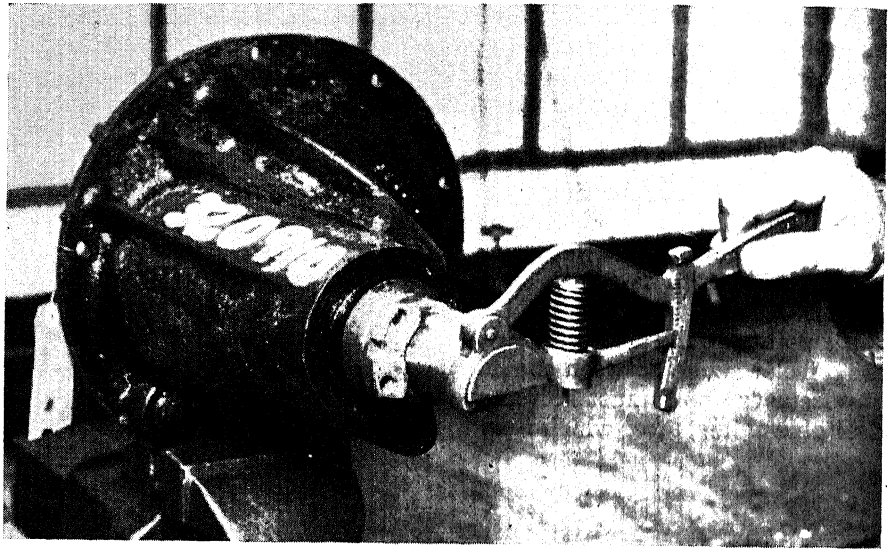


Fig. 1.—PRELOADING TEST ON DIFFERENTIAL PINION
A preload of 25-30 in./ lb. should be obtained.

Rear Axle

THE rear axle is semi-floating and has hypoid gears. The hubs are keyed on tapered half-shafts which butt at inner ends on hardened block. The Six and Eight had non-adjustable ball outer bearings in 1937, and tapered roller in 1938. Adjust by shims behind brake back plate (which retains bearing) to give 0·004–0·007 in. of end play. If end play is more than 0·050 in., adjust both sides equally.

The Super Eight has double taper roller wheel bearings. To adjust, withdraw axle shafts with outer bearing cup and inner bearing cone and rollers, remove inner bearing cup, and insert shims behind. End play is 0·002–0·004 in. on each shaft.

On models Six and Eight the pinion shaft runs on tapered rollers with

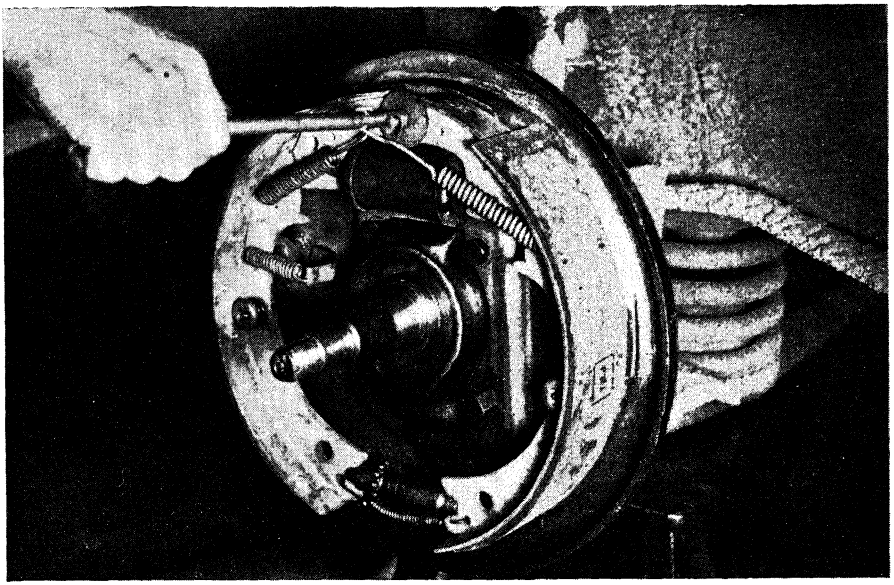


Fig. 2.—FIXING THE BRAKE SHOE SPRING
Showing also the correct way round of the primary shoe.

distance piece between. Adjust bearings by tightening self-locking flange nut until the distance piece begins to buckle, which should give preload of 25–30 in./lb. (A 5–6-lb. pull on a 5-in. spanner will rotate the shaft.) There is no mesh adjustment on the pinion shaft.

The differential bearings must be preloaded to spread bearing housings 0·010–0·012 in. Use large outside callipers and a 0·010-in. feeler against the machined bosses on bearing housings. Lock callipers, loosen caps slightly, and back off the offside bearing adjusting nut until differential assembly is loose in bearing. Back off the nearside nut, if necessary, to provide some backlash between crown wheel and pinion. Now tighten offside nut until callipers (without feeler) will just slide over bosses.

If backlash is more than 0·005 in., back off the offside nut and tighten nearside nut an equal amount until backlash is 0·003–0·005 in. If nuts are turned exactly equal amounts, preload adjustment will not be upset.

The Super Eight pinion shaft is straddle-mounted in two double-row, non-adjustable ball races. The shims behind the flange of outer bearing housing adjust pinion position.

The oil reservoir, formed by the rib of outrigger bearing housing, must be refilled every time the joint flange or pinion shaft is removed.

Differential adjustment procedure is the same as for the Six or Eight, except that preload should be 0·015-in. spread.

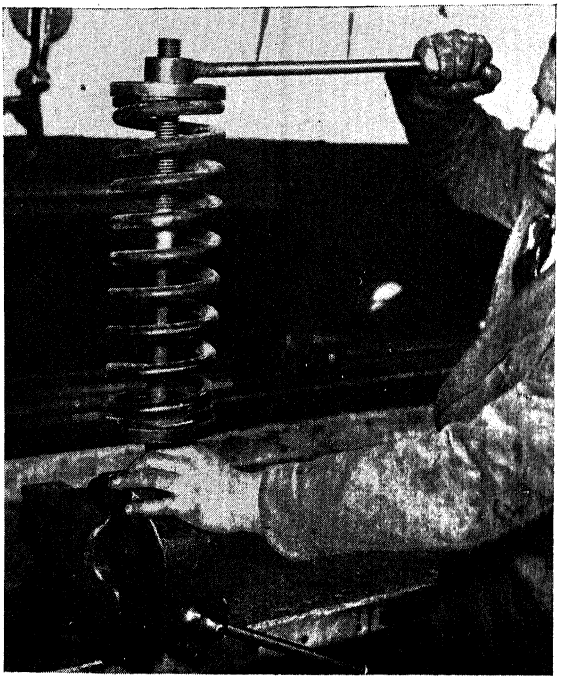


Fig. 3 (*left*).—METHOD OF COMPRESSING FRONT SUSPENSION SPRING

Brakes

Brakes are Lockheed hydraulic with Bendix shoes. The hand-brake works rear shoes by cable.

To adjust the foot-brake, jack up and remove all wheels. Remove the spring covers from adjuster slots at bottom of back plates and covers from brake-drum slots. Adjust rear shoe on each brake with 0·010-in. feeler through slot in drum at lower end by means of the eccentric at centre of shoe, and at upper end by eccentric anchor bolt at top.

Turn star wheel by screwdriver through slot at bottom until slight drag is felt, then back off until just free.

To adjust hand-brake, turn the star adjuster on back wheels until wheels can just be turned.

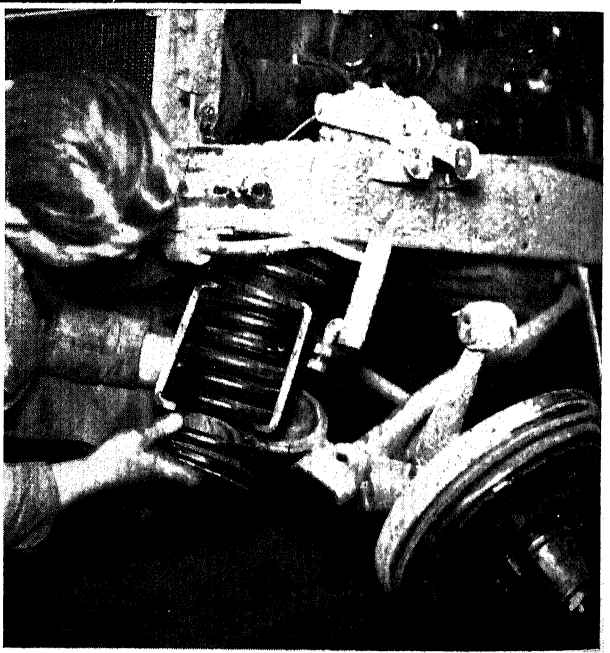


Fig. 4 (*right*).—INSERTING SPRING

Note clamps to keep spring compressed.

The next step is to set handbrake lever in first notch and disconnect both cables to rear wheels. Put equaliser bar at right angles to frame side members and adjust cables until clevis pins enter freely without moving bar. Assemble pins, release lever, and back off star adjusters until the wheels are free.

The pedal must have $\frac{1}{4}$–$\frac{1}{2}$ in. of free movement before engaging piston in master cylinder.

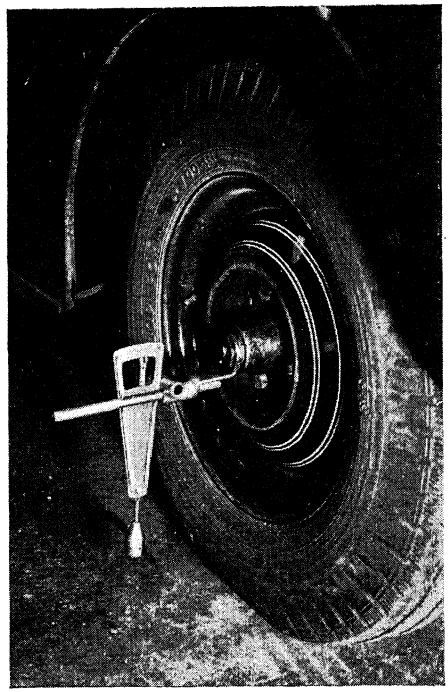


Fig. 5.—CHECKING THE FRONT WHEEL FOR VERTICAL

Front Suspension

Front suspension is independent, with coil springs. The long lower links have rubber bushes at inner ends and needle rollers at outer ends and are located by torque arms with rear ball ends in rubber bearings. The top wishbone links act direct on shock absorbers and have rubber bushes at outer ends with thimbles for camber adjustment. Thimbles are available with 0, $\frac{1}{16}$ in., $\frac{1}{8}$ in., and $\frac{3}{16}$ in. in offset. Offset of $\frac{1}{16}$ in. changes angle $\frac{1}{3}°$. Measure the camber angle with a load equivalent to four passengers.

The castor is adjustable by tapered shims between lower link and torque arm. Measure with the car loaded. Check for binding in wishbone and lower link inner bearings after adjustment.

Divided track rods have left- and right-hand threads. Turn both equally to adjust toe-in, making sure that the steering worm is in central position.

King pins are secured in the carrier arms by drive-in cotters. Welch plugs are fitted top and bottom. Knock out either way after drilling out plug. The king-pin bearings are Oilite bushes with ball thrust below wheel carrier.

Tapered roller wheel bearings are adjustable by tightening and backing off half a turn.

Rear Suspension

Rear suspension is by means of semi-elliptic springs 54 in. long and 2 in. wide, with rubber bushes at both ends. Do not lubricate the

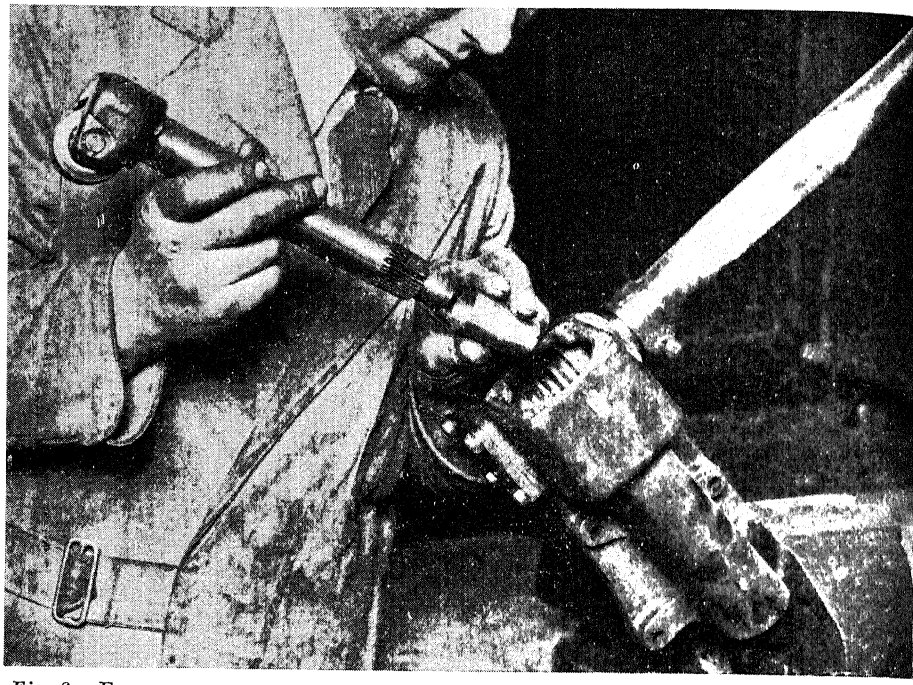


Fig. 6.—FITTING SAFETY COVER ON SHAFT TO PROTECT FELT LINING IN STEERING WHEN INSERTING SHAFT

springs. The covers act purely as dirt excluders. If shackles are dismantled do not tighten fully until weight of car is resting on the springs.

Steering Gear

Before making adjustments to the worm and double-tooth roller, disconnect the drag link from drop arm. If steering binds, loosen the frame bolts so as to align column to dash-bracket. Tighten frame bolts and release the dash bracket. Elongate holes or shim bracket, if necessary.

On the Six and Eight, three adjustments in the steering box should be carried out in this order :

Column up-and-down play.—Turn wheel to either stop and back $\frac{1}{8}$ turn. Loosen column bottom-end cover screws about $\frac{1}{8}$ in. and remove shims until slight drag is felt at wheel when cover is bolted up.

Cross-shaft end play.—With wheel near one lock, turn adjusting screw to take up all play.

Roller mesh.—Turn wheel to mid position and test drop arm for backlash. Remove drop arm and side cover plate and take out cross-shaft with roller. To prevent damage to oil seal at drop-arm end of shaft, tape the splines and withdraw shaft carefully. Remove shims behind

roller until no backlash is felt at mid position while shaft is held in by thumb-pressure.

Before refitting cover, back off end-play adjusting screw and readjust after tightening bolts.

Test wheel for slightly greater drag at mid position than on locks.

On the Super Eight, the column up-and-down play is adjusted as on the Six and Eight.

Roller mesh and cross-shaft end play are both controlled by adjusting screw on end of shaft. Remove cap nut and locking washer and turn screw with square-ended bar until slight drag is felt with wheel in mid position. Refit locking washer without altering adjustment and replace the cap nut.

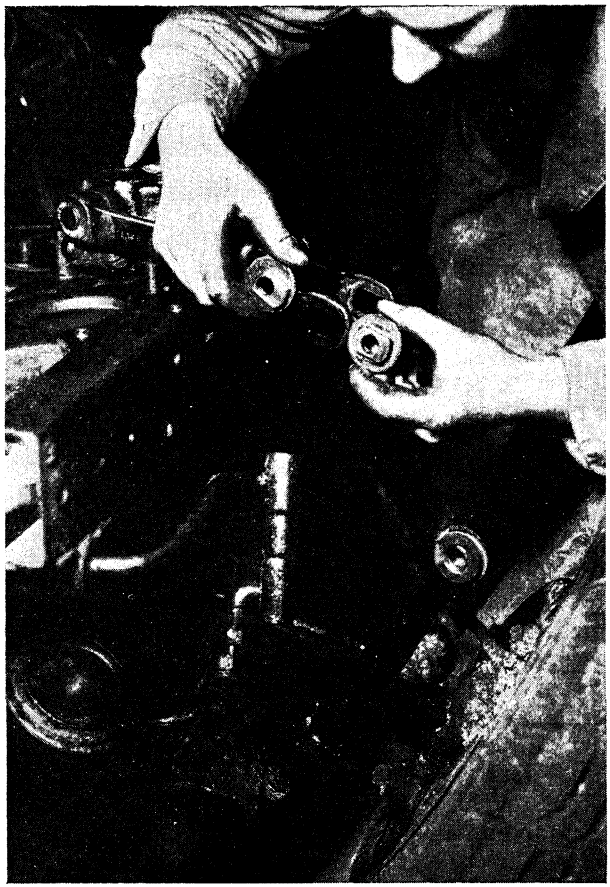


Fig. 7.—INSERTING DE-CENTRED BUSHES ON STEERING

Shock Absorbers

Packards are fitted with hydraulic double-acting, non-adjustable shock absorbers, Delco on Six and Super Eight, and Houdaille on Eight, 1938 and Delco on all 1939 models. Front shock absorbers are incorporated in the upper wishbone link. Rear shock absorbers on Six and Eight are mounted on the axle, offside arm to front, incorporating anti-roll bar, and nearside arm to rear.

Shock absorbers are mounted on the frame at the rear on Super Eight with an anti-roll bar between.

REPAIR AND MAINTENANCE OF TILLING-STEVENS CHASSIS

PROPELLER SHAFT, AXLES, STEERING, AND BRAKES OF PASSENGER (TYPE HA39A7) AND GOODS (TYPE HA39C4) MODELS

By F. J. HUGHES, M.S.A.E., A.M. INST. T.

PROPELLER SHAFT

Needle-bearing Type

OILS recommended: Mobilgrease No. 2, Castrol "D," Shell Spirax.

This shaft consists of two portions, the forward or intermediate half, from rear of gearbox through a self-aligning ball race in the main frame cross-member, coupled to the rear portion or propeller shaft proper.

The three joints are of the needle-bearing type, and apart from lubrication with gear oil every 3,000 to 4,000 miles, or fortnightly, require practically no attention. Lubricant is applied through a gun nipple on each trunnion cross, one for each joint, while the forward splined slip-joint end of propeller shaft proper has a gun nipple, also for gear-oil lubrication on the rear yoke.

Lubrication for the self-aligning bearing mounted in the cross-member is supplied from a nipple in the battery mounted on the cross-member just forward of the rear axle.

Dismantling

If it is desired to examine the needle bearings, the two lock-screws are first removed, then the lock straps and cover plates. The needle-bearing assemblies will then slide freely out of the yokes. Reassembling merely reverses the above process, the whole operation being possible without removing the joint from the chassis.

The rear portion or propeller shaft proper can be entirely dismantled from chassis by removing the eight flange-coupling bolts at each end. It is advisable to mark each pair of flanges so that they are replaced in the same place. When reassembling, it is important that all bolts and nuts are split-pinned.

Access to, or renewal of, self-aligning bearing in cross-member is

obtained by drawing off flanged end of shaft and removing dust cover on housing secured by six nuts.

When assembling slip joint on the shaft, care must be taken to assemble so that the sleeve yoke lugs lie in the same plane as stub ball yoke lugs. Arrows are stamped on sleeve and shaft for this purpose.

REAR AXLE

Oils recommended : Mobiloil " C," Castrol " D," Shell Spirax.

The rear axle is of the fully floating type with underslung worm and four-pin differential. Two axle ratios are available, 5·75 and 6·4, and each worm case is stamped on the offside rear with the ratio fitted.

An oil-level indicator and filler combined is fitted to the rear of each worm case, and the correct level is just below top of filler, which is exposed by opening the hinged lid. Gear oil is recommended for lubrication, and a weekly examination of oil level is desirable. This is best carried out when the axle is warm, as the oil flows more freely.

The front end of worm shaft is fitted with an adjustable packing gland to prevent oil leakage.

To tighten gland, release the two rear nuts and tighten the two forward nuts an equal amount, after which, the two rear nuts should be brought up and locked. Gland should not be over-tightened, and usually about two complete turns of adjusting nuts will be found sufficient.

Worm-shaft Oil Gland (Type HA39C4 only)

The gland housing is packed with three packing rings of special material, which alone should be used for replacement purposes.

To stop oil leakage, turn the gland nut in a right-hand direction until the worm-shaft can just be moved by hand ; compression of the packing to a greater extent than this will result in rapid wear of the shaft as well as of the packing.

The gland nut is retained in position by a steel locking-plate, which is held by one of the studs securing the gland housing to the casing. The locking-plate must always be refitted so as to engage with one of the slots of the gland nut.

To remove worm and wheel for inspection or adjustment, disconnect flanged joint at rear of propeller shaft by removing eight bolts. While this operation is in progress the oil can be draining from the worm casing through a plug hole for this purpose. Then disconnect Lockheed anchorage at each side of axle, one bolt and one set screw at the top end of each anchor plate, to allow Lockheed cylinders to swing clear of axle tie-rod nuts.

Axle tie-rod nuts should then be removed and rod lifted clear. From chassis 8778 onwards, it is not necessary to disconnect Lockheed anchorage to remove axle tie-rod. To remove tie-rod on these chassis, release tension by slackening turnbuckle, then, after removing split pins from each bar at end of rod, bars can be withdrawn and the rod lifted clear.

The nuts securing the rear-wheel driving dogs should next be removed and the driving-dog joints broken by means of forcing screws introduced in the two tapped holes provided. The two differential cross-shafts, complete with driving dogs, can then be withdrawn. After providing sling around unit, or packing under worm housing, remove the bolts securing the worm casing to the axle and break the joint by means of the forcing screws in the four tapped holes, when the complete unit, consisting of worm, wheel, and differential gear, can be lowered clear. This work is best carried out over a pit, otherwise rear axle must be raised to allow worm gear to be completely withdrawn.

Reverse the sequence of operations for reassembly.

Removal of Worm-shaft and Bearings from Worm Casing

(1) Remove the universal joint coupling from the tapered end of the worm-shaft.

(2) Remove the gland and gland housing.

(3) Remove the rear end-cover.

(4) Tap out the worm-shaft in a backward direction. The inner race of the front roller bearing will remain on the shaft ; the rear ball bearing and the ball thrust bearing will also remain on the shaft and can be removed after the locknut has been taken off.

Removal or Adjustment of Rear Hubs (Timken Bearings)

Lubricants recommended : Gargoyle Grease " BB," Castrolease Light, Shell R.B. Grease.

Having removed the wheels, remove nuts securing driving dogs, and withdraw shaft as detailed under rear-axle instructions. After wiping away lubricant, the locknut is exposed, held in position by a special locking washer bent down over one of the flats of the nut. Straighten out this washer by means of a screwdriver, or other suitable tool, after which the nut can be unscrewed in a left-hand direction on nearside and right-hand on offside. Then pick off locking washer and tongued washer next to it, afterwards unscrewing the special disc with tool provided in equipment. The hub is then ready for removal and examination of bearings, etc.

Reverse the sequence of operations for reassembly.

Adjustment is best accomplished by drawing up the adjusting or inner nut reasonably tight, and at the same time rotating the hub several times. The object of this is to ensure that all component parts of the bearing are properly seated in the interior of the hub. After having drawn the adjusting nut up tightly, it should be backed off one-third or one-half turn to a point where the wheel is free running, but not sufficient to permit of more than just the least perceptible shake in the bearings. The adjusting nut should be locked in the final position.

The two threaded nuts, with key washer between, form a combination

in which the inner nut is positively locked against rotation, while the outer nut clamps the parts solidly together. By offsetting the tongue, or flat, in the key washer one-quarter of the hole spacing, an increment of adjustment of one-half the hole space is possible by reversing the key washer.

Springs and Shackles

The spring clamping bolts on both axles should be kept tight to prevent broken springs and brake troubles. All spring shackles are lubricated by grease-gun from grouped nipples placed in accessible positions, and clearly indicated in lubrication diagram.

The springs should be kept reasonably clean in order that a broken leaf may be readily apparent. In addition, a spring kept in good condition and free from rust gives better riding qualities.

It is considered a good plan to separate, periodically, the spring leaves, and introduce graphite grease by means of a knife blade, or steel strip, to further increase riding comfort, and obviate those annoying little squeaks so prevalent on many vehicles kept in continual service. The separation of the spring leaves is best affected by taking the weight off the spring to be so treated, then after slackening the clamping bolts and clips the leaves can be forced apart by a chisel or stout screwdriver.

STEERING

The steering gear is a Marles cam and roller type with an overall reduction of 20½ to 1. About three and three-quarter turns of the steering wheel are required for turning from one full lock to the other.

Steering Box

No adjustment of the cam and roller or of the bearings in the steering box will be required until a lengthy period of service has elapsed, but in the event of accidental damage, which necessitates the dismantling of the box, the following methods of adjusting the engagement of the roller in the cam, and of the cam bearings, should be followed :

Adjustment of Cam and Roller Engagement

(1) Remove the drop arm from the rocker-shaft, taking care first of all to mark both so that they may be refitted in the same relative position.

(2) Remove the rocker-shaft from the steering box.

(3) Remove the nut and lock-washer from the rocker-shaft bolt, and withdraw the bolt about ⅜ in., so that its serrations near the threaded end are just clear of the serrations in the rocker-shaft hole.

(4) Adjust the depth of engagement by turning the bolt with a spanner. The engagement should be close enough to ensure that there is no trace of backlash when the roller is in the *centre* of the cam, and only a slight

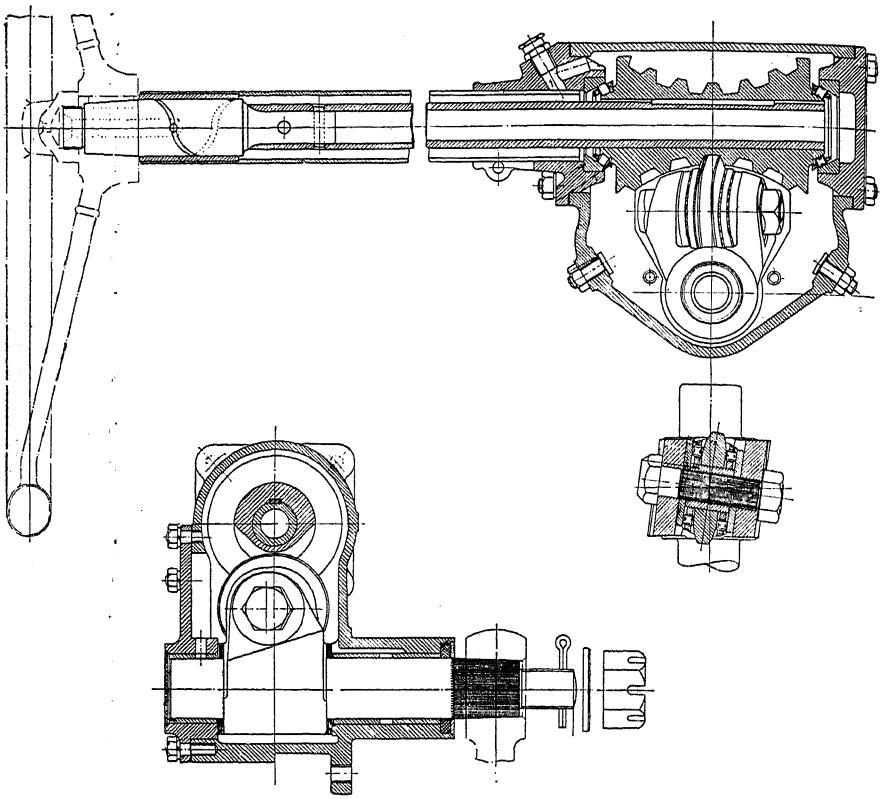


Fig. 1.—THE STEERING GEAR

amount at the extreme ends of the cam-and-roller movement. (The roller assembly is mounted on an eccentric distance piece, and turning the bolt clockwise will raise the roller into the cam.)

(5) Push the bolt home again into the rocker-shaft and replace the lock-washer and nut.

Adjustment of Cam Bearings

(1) Unbolt the column support from the steering-box casting.

(2) Remove or insert one or more shims (Part Nos. 2616 and 2617) between the column-support end face and the box casting, so that the cam has no end-play when the column support is again bolted in place. Similar shims are inserted between the box casting and the bottom cover, but these should not be disturbed, as they are for centring the cam relative to the rocker-shaft.

Steering Side-tube and Tie-rod

The steering side-tube has ball-and-socket joints which are provided with strong springs to take up wear. For convenience in the assembling of the chassis, the tube is made adjustable for length ; its correct length is set at the works and must not be altered.

The ball socket housings of the tie-rod are screwed right- and left-hand on to the ends of the rod and secured by pinch bolts. After any adjustment to the length of the rod, the pinch bolts must be well tightened and the nuts must be split-pinned.

Alignment of the front wheels should be checked periodically, and the wheels kept between parallel and a "toe-in" not exceeding $\frac{1}{8}$ in. measured at the height of the wheel centres ; any deviation from this will result in excessive tyre wear.

The lock of the front wheels is limited by adjustable stops fitted at the front ends of the axle-bed. It is *most important* that the axle stops, on either side, should come into action *before* the stops in the steering box ; damage to the roller assembly will result if the steering-box stops are used for limiting the lock of the front wheels.

Frequent and regular lubrication of all parts of the steering gear, and of the front-axle pivot pins and thrust bearings, is necessary to retain ease of steering.

FRONT AXLE

The front axle-bed, which is of channel section, is a heat-treated alloy-steel forging. Phosphor-bronze bushes are provided for the swivel pins, and the load is taken on tapered roller thrust bearings.

The front hubs run on tapered roller bearings, which have a simple means of adjustment.

If it should be necessary to straighten the axle-bed after an accident, it is important that it should be correctly heat-treated afterwards. *In cases of emergency only*, when proper facilities for heat-treatment are not available, the axle-bed may be heated in a smith's forge, for instance ; but great care must be taken not to heat it beyond incipient red, that is, a barely visible red when viewed in the shade or in a dull light. If a smith's forge is used for heating-up, it is most important that the heating be done gradually so as not to overheat the edges of the flanges.

Adjustment of Swivel-pin Thrust Bearings

(1) Jack up the axle to remove the load from the bearing.

(2) Take off the bearing cover and extract the split pin.

(3) Swing the pivot to and fro, and whilst doing so screw down the swivel-pin nut until the swivel can only just be moved.

(4) Unscrew the swivel-pin nut a sixth of a turn.

(5) Refit the split pin and replace the bearing cover.

The rear brakes are fitted with $\frac{9}{16}$-in. and the front with $\frac{1}{2}$-in. adjusting setscrews at the extremities of each cam lever, all facing forward.

The adjustment operations are similar for all four brakes, so that a description covering one single adjustment is sufficient for all.

First slacken locknut, and then turn setscrew clockwise to take up wear, and anti-clockwise to increase clearance. When correctly adjusted there should be approximately $\frac{3}{32}$-in. clearance between end of setscrew and button on Lockheed cylinder lever, or alternatively, not less than ·008 in. between brake liners and drums, which can best be ascertained by feeler gauge. Once the correct adjustment has been obtained, carefully tighten locknut on setscrew.

To adjust Hand Brake on all Chassis up to No. 8778

The hand brake operates on the small rear drums only. The adjusting nuts are situated at the ends of the rods connected to the brake-cam levers, just forward of the rear axle. It is recommended this brake is adjusted when hand-lever range exceeds three-quarters of its travel.

Slacken the forward adjusting nut and follow up with rear nut until the range of hand lever has been reduced to approximately one-third travel. The forward nut should then be securely tightened. Although a balance link is fitted, it is preferable to make sure each side has the same amount of travel, and not only to see that the shoes come into contact with the drums simultaneously, but also are clear of the drums when brake is "off."

To adjust Foot or Hand Brakes on Chassis 8778 onwards

When pedal or hand lever exceeds approximately three-quarters of its range, the brakes should be adjusted independently front and rear by the setscrews on the cam levers supplied for this purpose. The actual adjustment operations are similar to those already described under "Foot Brake."

No foot- or hand-brake adjustment is necessary other than already described. Do not on any account alter rod lengths from pedal to servo, or from servo to Lockheed master cylinder tank.

Shock absorbers are not fitted as standard.

RADIATOR

If the vehicle is to be left standing for any length of time in an unheated place during frosty weather, all water should be drained from the radiator and engine, by the removal of the plug in the bottom tank and the opening of the drain taps on the water pump and the water-inlet pipe to the cylinder block. When water ceases to run out, the engine should be started up and allowed to run for a few moments to get rid of the last traces of water.

REPAIR NOTES ON S.S. JAGUAR CARS

REAR AXLE, BRAKES, FRONT AXLE, STEERING, AND SPRINGS, ON 1½-, 2½-, AND 3½-LITRE

By D. H. WARREN

Rear Axle

TO take out the axle centre assembly, the dismantling sequence is as follows :

(1) Disconnect rear prop shaft flange.

(2) Remove wheels, brake drums, and anchor plates.

(3) Take out bolts holding axle end-pieces to main banjo and withdraw axle shaft and hub complete.

(4) The axle centre piece is then free to withdraw after undoing the nuts which hold the surround flange to the banjo.

The repairer will be well advised to make use of the special service facilities for differential units provided by the works. It will be realised that silent running of the gears is sometimes difficult to obtain once their mesh has been disturbed or even when new gears have been fitted, unless it is possible to bench test under working conditions. In addition, in some cases certain modifications have been introduced by the manufacturers to provide greater strength. S.S. Cars Ltd. are in a position to service on very economical terms any differential assembly which may require attention, and a service axle-centre assembly may be obtained on application.

After considerable service, the axle shafts may develop end float. This can be adjusted out by jacking-up *both* rear wheels, withdrawing one shaft and taking out one or more of the shims, which are fitted between the banjo end-piece and hub retainers. It is necessary to leave ·006-in. end float after adjustment.

Brakes

All S.S. Jaguars are fitted with the well-known " Girling " brake system. Ordinary adjustment is effected by means of the adjustors on each brake-carrier plate, and under normal circumstances it is not necessary to interfere with the setting of the brake rods.

The brake shoes are readily accessible for replacement after removing wheels and drums, and it is always advisable to obtain from the manufacturers or authorised dealers service brake shoes where linings on the old shoes have become worn. Replacement brake shoes are fitted with

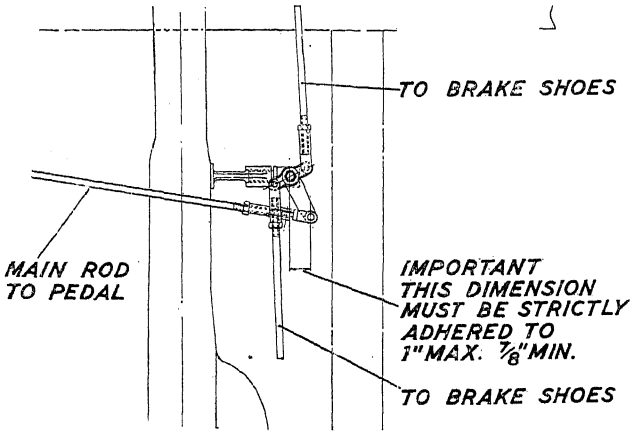


Fig. 1.—GIRLING BRAKE ROD COMPENSATOR LEVER SETTING—"OFF" POSITION

linings which have been finished and ground to shape, and on returning the original shoes a proportionate allowance is made.

Due to possible ingress of mud, etc., the expanders may tend to become seized after a period of service, but with the drums removed it is a simple matter to withdraw the cones and plungers for cleaning and lubricating. In addition, it must be remembered that the expander housing should be free to slide on the brake-carrier plate.

If, for any reason, the setting of the brake rods is disturbed, it is firstly necessary to set the transverse rods on both axles so that the compensator lever attached to each axle gives maximum leverage when brakes are applied. The "off" position of the lever is shown in Fig. 1. In connecting up the main front and rear rods, they should be adjusted in length so that the swinging linking behind the foot pedal is parallel with the chassis cross-members when brakes are applied. On 1938/39 models the right setting is obtained when the stop-pin for the main compensator is central in clearance hole with brakes "off" (see Fig. 2). Make sure that brake-rod coupling unions are tightened securely and that each clevis pin is safely split-pinned. It is usual for all clevis pins and jaws to be slack fit.

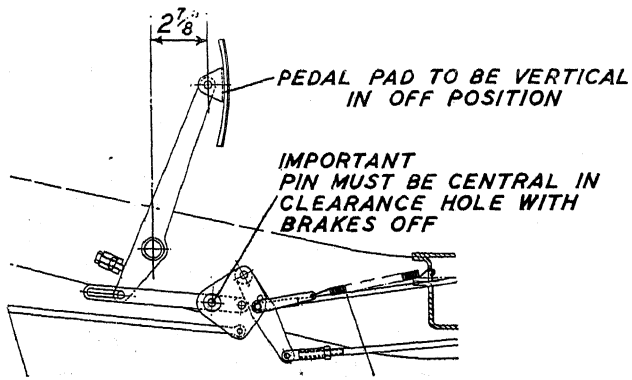


Fig. 2.—GIRLING BRAKE SETTING (1938/39 MODELS)

Front Axle

The front hubs are fitted with "Timkin" taper-roller bearings, and

where looseness in the hubs develops it can usually be taken out by tightening up the adjusting nut which will be seen inside the hub shell. After taking out the split pin the nut should be pulled up by finger pressure and then released about one castellation, it being necessary to leave a slight perceptible shake in the front hub when fully adjusted. The procedure in dismantling stub axles is as follows :

(1) Remove wheels, brake drum, and brake-carrier plate, complete with shoes.

(2) Take out swivel-pin cotter in axle beam and knock off swivel-pin top dust-cap which is riveted to the pin. The pin can then be knocked out in a downward direction and the stub axle is thus released. New bushes, if necessary, are pressed into the stub axle and will need a little scraping-in.

If the swivel thrust bearings as fitted to the 2½- and 3½-litre models are pitted, they should be replaced.

Front Springs

The front eye is phosphor-bronze bushed and is released by withdrawing the shackle pin. On all models other than 1936/37 1½-litre, the rear end of the front spring slides between phosphor-bronze trunnions enclosed in a bracket attached to the chassis frame. Unless due to neglect these trunnions do not wear, but a sharp knocking noise can occur due to lack of grease or after fairly high mileages, due to sideplay of the spring in the trunnion bracket. In such cases, side play can be adjusted by taking out one or more of the shims which are placed between the trunnion side plate and bracket proper. The lead-coated springs, as fitted from 1937 onwards, should not be lubricated.

Steering Column

The steering head controls, complete with tubes, are withdrawn from the top after releasing in the following manner :

(1) Disconnect horn and trafficator leads in junction box on steering-box cover.

(2) Take off ignition-control lever below steering box.

(3) Slacken off setscrew on clamp at steering-box base, i.e. the clamp locating the outer control tube.

(4) Take out two small grub-screws in steering-wheel boss.

The steering wheel is splined on to the inner steering tube and its top movement is restricted by a circlip which is accessible after taking out the central head. Slackness in the top column thrust race may be taken out by adjusting the thrust-race adjusting nut, above which is a locking nut. The complete steering column may be removed from the chassis after dismantling the wheel and controls as above described, disconnecting the steering-box bracket on the chassis frame, and then lifting and drawing

out the complete unit towards the front. Operations are facilitated by first removing the offside headlamp.

Shock Absorbers

"Luvax" hydraulic shock absorbers are fitted to all models. It is unwise to interfere with the valve adjustment of the vane type unless strictly necessary, as the only maintenance normally required is topping up the oil level. Special "Luvax" oil must be used for this purpose, and the oil level should be maintained to within about $\frac{3}{4}$ in. of the top of the chamber. If required for any reason, the relief-valve adjustment will be found beneath the filler plug.

The piston-type shock absorber fitted on later models have no adjustment, and a special fluid, different from that for the vane type, must be used for topping up the oil level.

Removing Starter Motor (1½-litre models)

As there is little clearance round the starter motor it is necessary to move aside the steering box. To do so the steering-box main attachment bolt should be taken out, when it will be found that the column can be moved sufficiently to clear the starter. On 1938 models the same procedure may be applied unless it is preferred to remove the sump.

Rear Springs

On all models the rear springs are fitted with silentbloc bushes which require no lubrication. From 1937 and onwards the springs are lead coated, and it is inadvisable to lubricate the spring leaves, as this tends to make them too flexible.

The rear springs are removable after driving out the shackle pins and disconnecting the U-bolts. The rear shackle pin can be reached by lifting out the rear boot floor.

HUMBER INDEPENDENT FRONT-WHEEL SUSPENSION

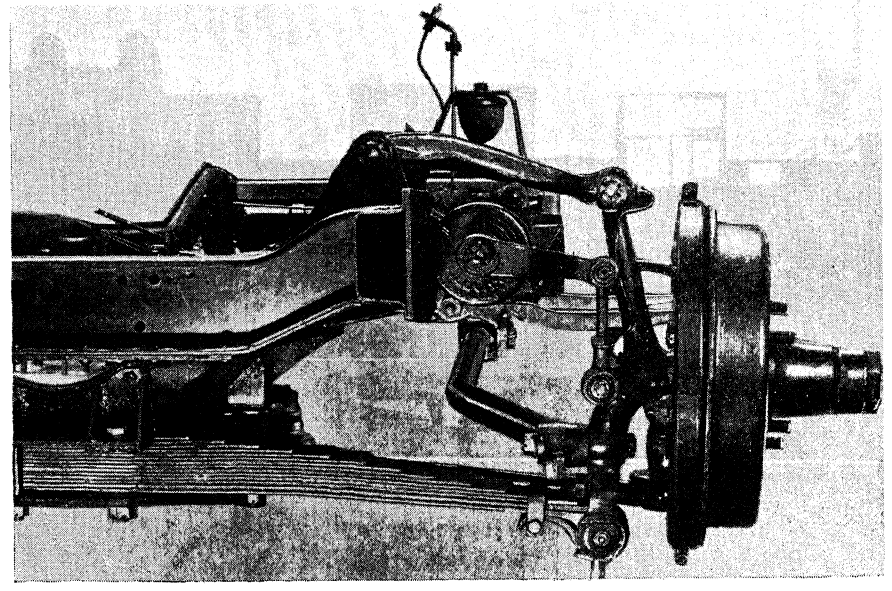


Fig. 1.—GENERAL VIEW OF SUSPENSION
(Imperial and Pullman Models.)

IN writing on the subject of Humber independent front-wheel suspension, it is felt that, to avoid confusion, it would be advisable to divide this article into two parts: (1) The suspension fitted to the Pullman and Imperial; (2) a slightly modified type fitted to the Super Snipe, Snipe, and Sixteen models.

SUSPENSION ON IMPERIAL AND PULLMAN 1939 MODELS. ALSO ON 1936–7 18-H.P., 1936–7 SNIPE, 1938 SNIPE IMPERIAL

General Description

The term "Evenkeel Suspension" is used to indicate that these improvements in the suspension, which at first sight appear to concern only the front wheels, do, in actual fact, improve the riding in the rear

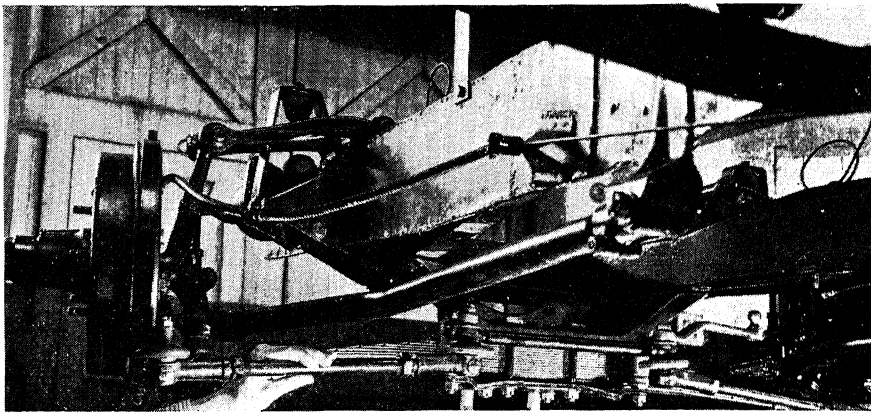


Fig. 2.—TRACK-ROD ADJUSTMENT
(Imperial and Pullman.)

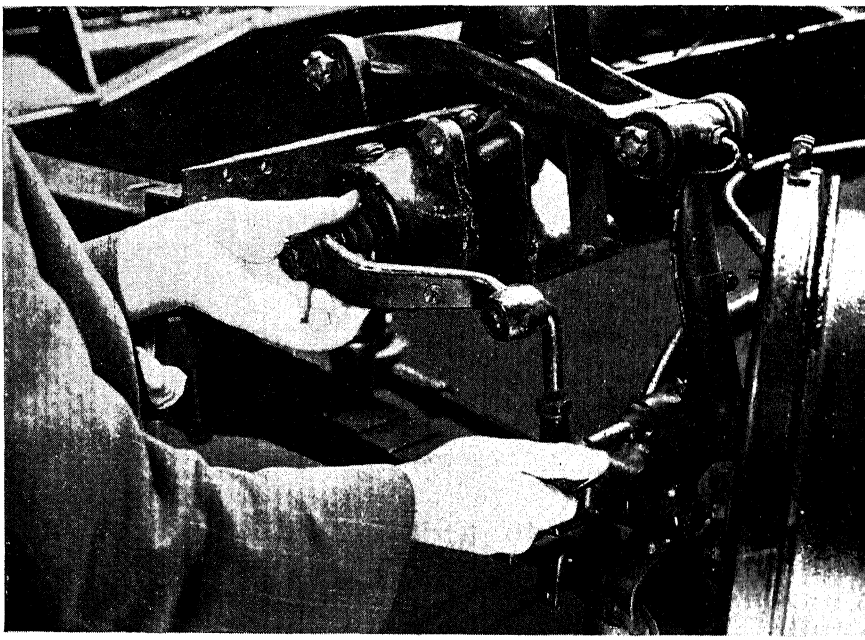


Fig. 3.—SHOCK-ABSORBER REMOVAL
(Imperial and Pullman.)

seats. With the orthodox rigid axle suspension, it is necessary to limit the vertical movement of the front wheels on account of the fact that the bulk of the steering gear moves with the front wheels, whereas with the independent-suspension system incorporated in this case, the wheel movement has no effect on the steering, and thus a vertical wheel movement, approximately equal to similar movements of the rear wheels, is obtained.

The front springs, therefore, absorb the road shocks as effectively as the rear springs, and thus there is no transmitted effect from the front which is apt to pre-compress the rear springs, leaving them in an unsuitable condition to receive their own road shocks.

From an examination of Fig. 1, it will be seen that the suspension consists of the portion carrying the stub axle, known as the stub carrier, which is hinged relative to the chassis frame on an upper link or wishbone, the leaf spring itself forming the lower link. It will be noted that the lower link thus formed is considerably longer than the upper link and it is, therefore, a matter of simple geometry to arrange the layout so that the wheel track does not vary with the movements of the spring, such lengthening of the spring being absorbed by very slight alterations to the wheel camber. In other words, instead of the whole wheel swinging outwards, as it would at first appear, the track in contact with the ground remains constant, whilst the other extremity of the wheel moves outwards when the spring is flexed.

As will be well known, the eye of a leaf spring does not move in a true radius about the clamp of the spring, but at a point approximately a third of the distance to the eye, so that if the track rod is hinged at the same point, it will move parallel with the lower leaf of the spring, and thus vertical wheel movements will not introduce a steering reaction, one of the most important advantages gained by this form of suspension.

The Track Rod

The track rod is, therefore, divided into three portions, the centre portion being a rigid link connecting the two centre steering levers; the ball joint connecting the steering to the box is incorporated on one of these centre steering levers, which is built rigidly on the chassis frame, and thus this section of the steering gear does not move at all when the wheels encounter road undulations.

The bearings in the spring eyes and also the bearings at each end of the top link are parallel one with another, so that the wheel movement is truly vertical when regarded from the side. All steering angles are arranged in the stub carriers themselves, so that in the event of this suspension being damaged in an accident, causing any of the steering angles on one side to disagree with those on the other side—and yet it be found that the six bearings are parallel one with another—it is a definite

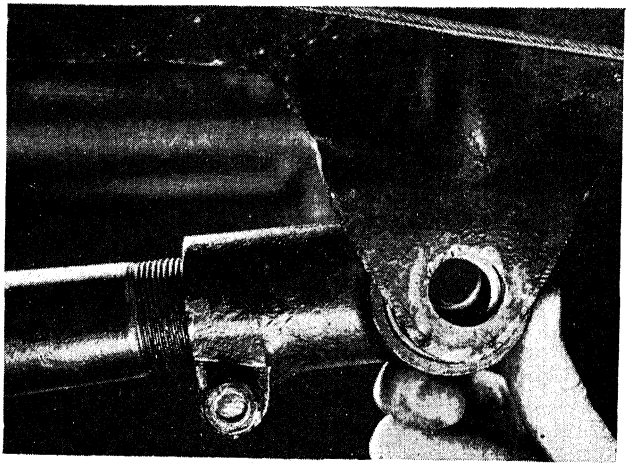


Fig. 4.—TORQUE ROD INCORRECTLY ADJUSTED
(Imperial and Pullman.)

indication that the stub carriers themselves are bent. Details of the steering angles are given later.

MAINTENANCE SERVICE

Lubrication

From two nipples fitted on each front wing below the bonnet, engine oil is fed to the bearings of the top link, and from that point passes along an external pipe down the stub carrier to the swivel pins, an arrangement being made internally in the swivel pin so that the top bush receives the lubricant before it flows by gravity to the lower bush and thrust bearing.

These oil nipples should be lubricated every 500 miles, and at the same time the front shackle pins should also be lubricated with engine oil.

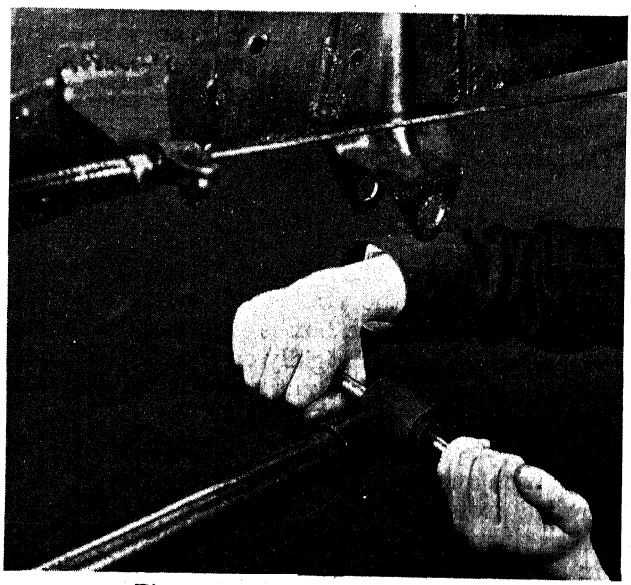


Fig. 5.—TORQUE-ROD ADJUSTMENT
(Imperial and Pullman.)

The only other points on this suspension requiring lubrication attention are the ball joints of the steering linkage. These should be greased every 1,000 miles. The other bearings are either packed with lubricant during assembly or do not require lubrication.

On later models the front spring is covered by leather gaiters, and it should be noted that only certain lubricants are advisable. Softer lubricants are inclined to run out and stiffer lubricants will not penetrate between the leaves. The lubricant recommended is Shell Retinax.

Track Rod

Periodically, particularly when the vehicle is new and the spring is settling, the toe-in of the front wheels should be checked, this being tested in an ordinary manner on the treads of the tyres at the height of the hubs. Should it be found necessary to adjust the track rod, this is carried out on the two side track rods, and great care must be taken to maintain these two track rods at equal lengths. When the adjustment is completed, it must be checked by measuring across the greasers incorporated in the ball joints.

Shock Absorbers

The shock absorbers are of the constant-pressure type which give the maximum resistance to low-pressure movements, such as roll, but owing to their special design, work as normal shock absorbers when submitted to high-pressure movements, such as those caused by the ordinary wheel movement over undulating roads. These shock absorbers should not be adjusted, but should be periodically topped up with the recommended Luvax fluid.

Torque Rods

It will be seen that massive torque rods are fitted between the chassis frame and the stub carriers. Actually, these torque rods are not connected with the actual suspension, but are fitted to absorb the brake reaction. As these torque rods are of considerable length, it will be appreciated that the ends describe a very wide arc, which is, to all intents and purposes, a straight line, similar to that described by the stub axle. The slight difference is absorbed by the rubber bushes on which the torque rods are carried.

Should it be necessary to adjust the torque rods, the end pivoted on the chassis frame should be released and the car raised by a jack placed directly under the centre of the spring. When the front wheels leave the ground, the bush in the rear bearing should be compared with the holes in the chassis frame bracket, and adjustments carried out so that these coincide ; the pin can then be easily inserted.

As it is at all times undesirable to place unnecessary strains on these silent-bloc bushes, the car should be lowered and allowed to assume its normal loaded position before the silent-bloc bushes are clamped.

Steering Ball Joints

The four ball joints incorporated in the track rod are of the self-adjusting type, but the two ball joints on the drag link are adjustable, the

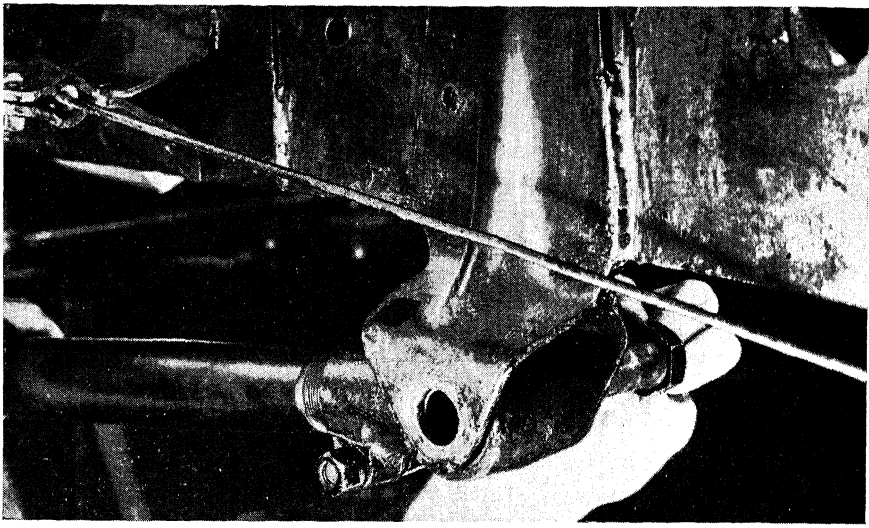


Fig. 6.—TORQUE ROD CORRECTLY ADJUSTED
(Imperial and Pullman.)

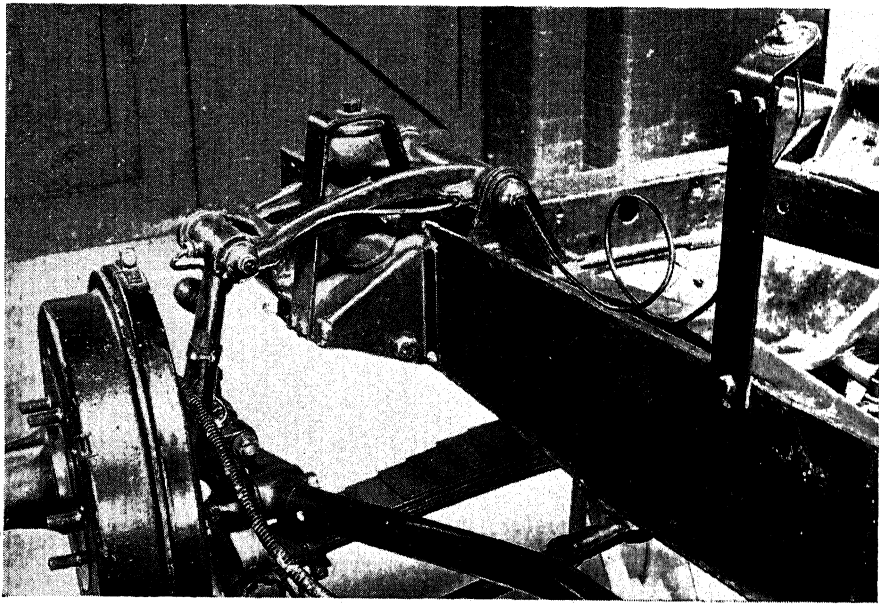


Fig. 7.—OIL-PIPE LAYOUT
(Imperial and Pullman.)

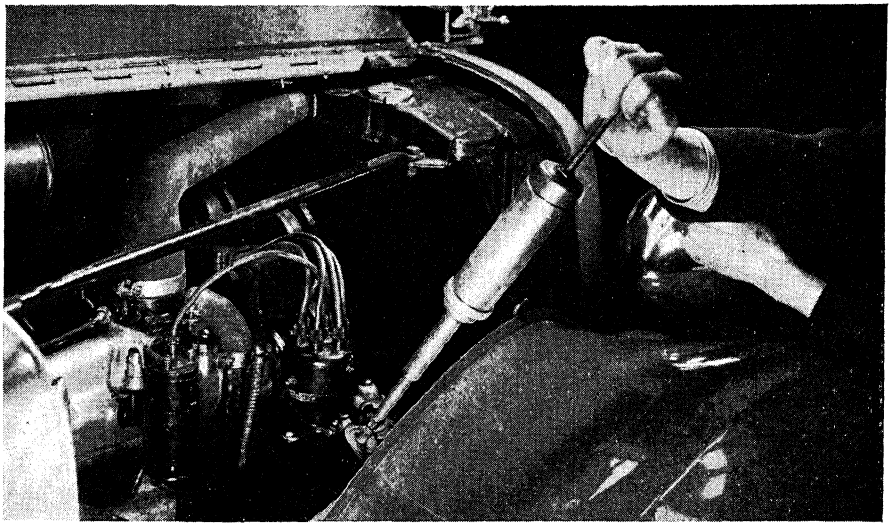


Fig. 8.—LUBRICATION
(Imperial and Pullman.)

correct adjustment being to tighten both end caps fully, releasing each of them until the first pin holes are reached.

GENERAL NOTES

(1) The bearings of the top link and also those in the spring eye are of the same construction, consisting in each case of flanged bronze bushes which are pressed in. These operate on hardened steel distance-pieces fitted over the actual bolts.

Upon considering this design, it will be seen that the length of the distance-pieces controls the end float of the bearings. This should be at least ·003 in. in each case, and in this respect it is interesting to note that by tightening the nut excessively the end float can be absorbed, causing the bearing to operate stiffly. Such conditions must be avoided, and it is advisable to check this end float by the insertion of a feeler gauge after the nuts have been tightened.

(2) The static spring camber can be tested accurately by the method described later in the steering angle and dimensions section, but the normal loaded position can be taken as being when the spring is flat or showing a slight reverse camber.

(3) The position of the lower leaf of the spring, being part of the steering geometry, must not be altered. Care must therefore be taken to replace the packing pieces in the correct position, should the spring be dismantled.

(4) The linkage system at all times must operate freely, and if any difficulties are experienced, such as excessive front-tyre wear, the first point to check is the freedom of these parts.

Steering Dimensions

The following are the steering angles and dimensions taken when the spring is in its static or normally loaded position.

Static Spring Camber, $\frac{3}{8}$ in.

This camber is measured by stretching a piece of string across the shackle-pin greasers, the measurements being taken from this piece of string to the lower face of the master leaf of the spring.

Castor angle	1° 30′
Wheel camber	2°
Slope of kingpin . . .	7° 30′
Toe-in	$\frac{1}{8}$ in.

SUSPENSION ON SIXTEEN, SNIPE, AND SUPER SNIPE, 1939, ALSO FITTED TO 1938 SIXTEEN AND SNIPE

Upon examining this layout, it will be seen that the transverse leaf spring forms the lower link, whilst the upper link is a very rigid "wishbone" mounted on long bearings. Between the extremities of this upper and lower link the swivel pin is mounted.

Suspension Bearings

Screwed or threaded bearings are incorporated in the suspension, the pivots and the bushes being threaded so that a larger bearing area is obtained, and end float on the bearings eliminated.

In refitting these bearings it is important that clearance should be left so that the bearing can screw into the bush without the shoulders on the pivot fouling the ends of the bush. In the case of the "wishbone" bearings this is a simple matter, as the bushes are only clamped in the wishbones. When the car is in its loaded position, the clamping bolts should be slackened and the bushes turned until a balanced end clearance of approximately $\frac{1}{8}$ in. is obtained at either side.

The procedure is not quite so simple in the case of the screwed bush in the spring eye. In this case it will be realised that the end clearance depends upon the start of the threads in the spring eye bush, and these bushes should be pressed in to the spring eyes so that the start of the threads is at the 12 o'clock position. It will then be found, if care is taken that an equal end clearance is obtained with the spring in the fork at the bottom of the swivel pin. A slight readjustment of this matter may be necessary in a very few exceptional cases.

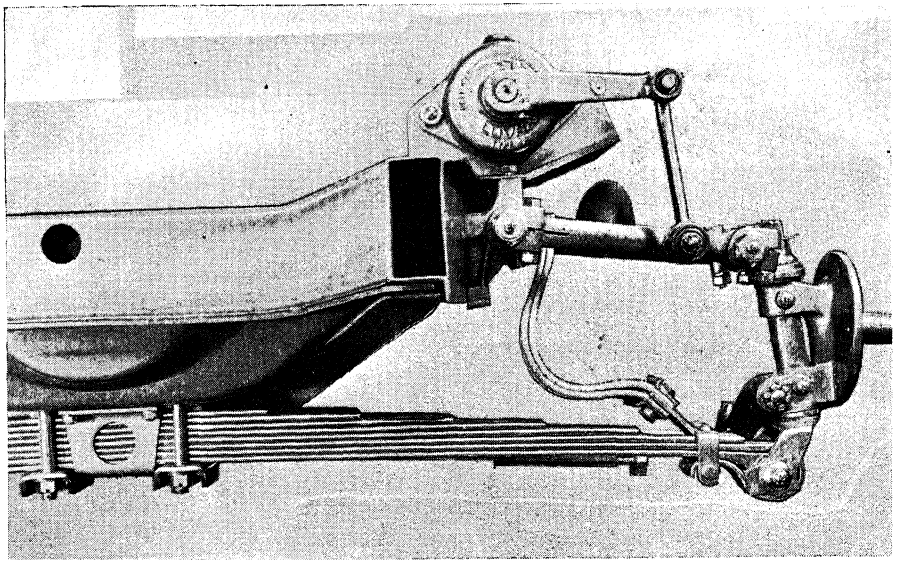


Fig. 9.—GENERAL VIEW OF SUSPENSION
(16-h.p. Snipe and Super Snipe.)

The transverse pin at the top of the steering kingpin is in the form of an eccentric, so that the wheel camber can be adjusted. In this respect it should be noted that the camber can only be upset by the replacement of either the chassis frame, "wishbone" or road spring, and thus the adjustment once obtained should not be altered unless contingencies of this nature are encountered. It will then be necessary to check and adjust the wheel camber, for which one of the many gauges marketed should be used.

Track Rod

This system of independent suspension is quite straightforward and entirely foolproof, except in dealing with the track rod and the position of the ball pins generally.

Upon examining the steering it will be seen that one track rod is considerably shorter than the other one, and it will furthermore be found, upon examining the layout more closely, that the ball pin on one stub axle is higher than the ball pin on the other stub axle. This is all a matter of careful geometry to ensure that steering reaction is not introduced by the movements of the front wheels over road undulations within the limits of the working range.

To explain this point, it is necessary to consider carefully the geometry

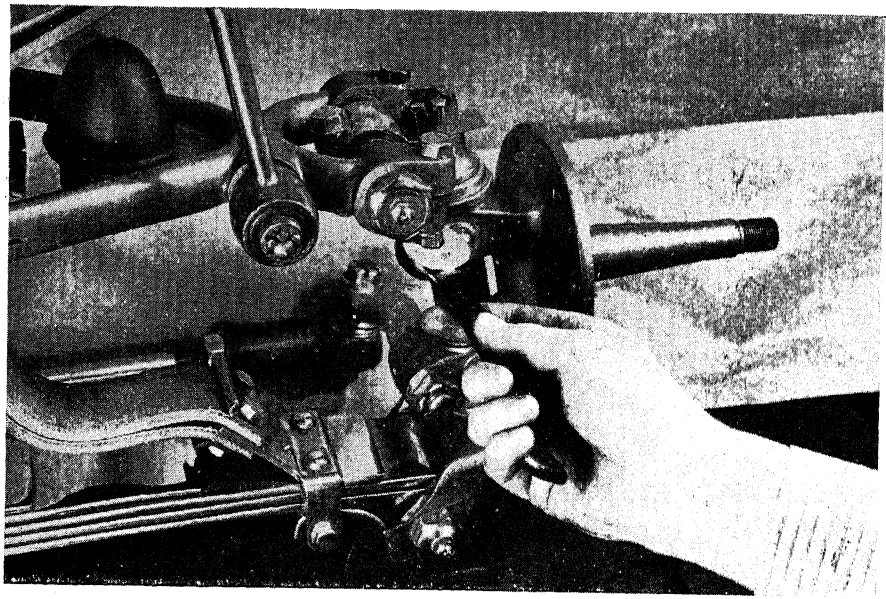


Fig. 10.—CLAMPS HOLDING BUSHES
(16-h.p. Snipe and Super Snipe.)

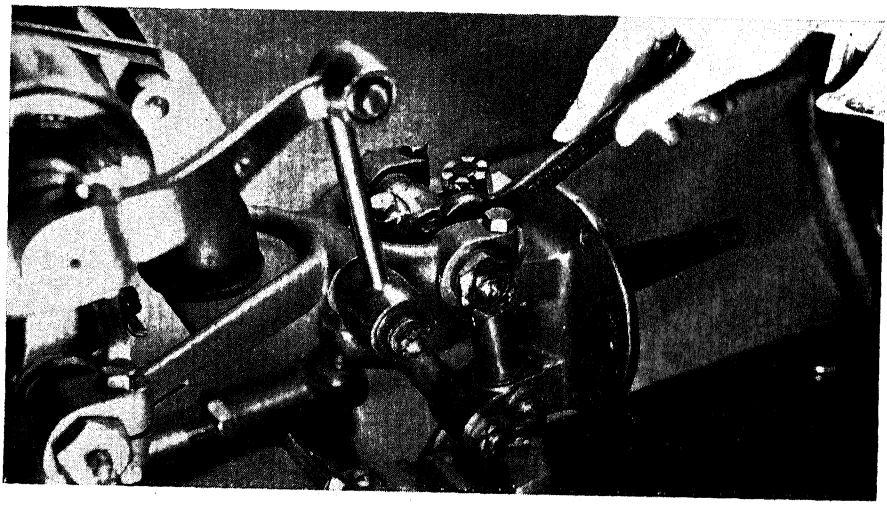


Fig. 11.—WHEEL-CAMBER ADJUSTMENT]
(16-h.p. Snipe and Super Snipe.)

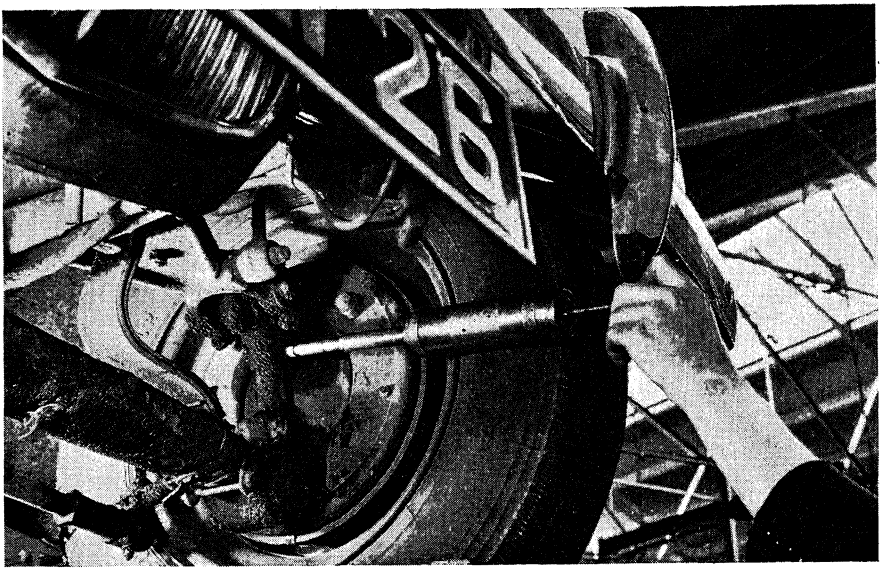


Fig. 12.—LUBRICATION
(16-h.p. Snipe and Super Snipe.)

as a whole. The upper link is considerably shorter than the lower link. This is so that the wheel track scarcely varies with the wheel movements.

To emphasise this fundamental point, it should be pointed out that, while the spring eye is moving outwards through a wide arc, which would tend to increase the track, the outer bearing of the " wishbone " is also moving outwards through a shorter arc, and this compensates for the movement of the spring eye, and, whilst the track remains almost constant, the wheel camber is altered slightly by the vertical wheel movements.

It will be seen from the above that in the stub axle assembly we have two points moving through two arcs of different radii. At any point between the upper and lower bearings of the stub-axle assembly, an arc of intermediate radius is described ; thus the ball pin is set on the stub axle so that it moves through an arc, the radius of which is the same as the track rod coupled to it. Track rods could, therefore, be used of any length which is shorter than the lower link, i.e. the leaf spring, or longer than the upper link, always providing that the centre about which it moves is definitely determined. This is the case with the short track rod.

The important point about the above is that an alteration to even such a small matter as the rake of the steering column will considerably upset the steering layout of this suspension, and if any cases of difficulty are experienced, these ball-pin positions must be checked up in accordance with the table of dimensions given.

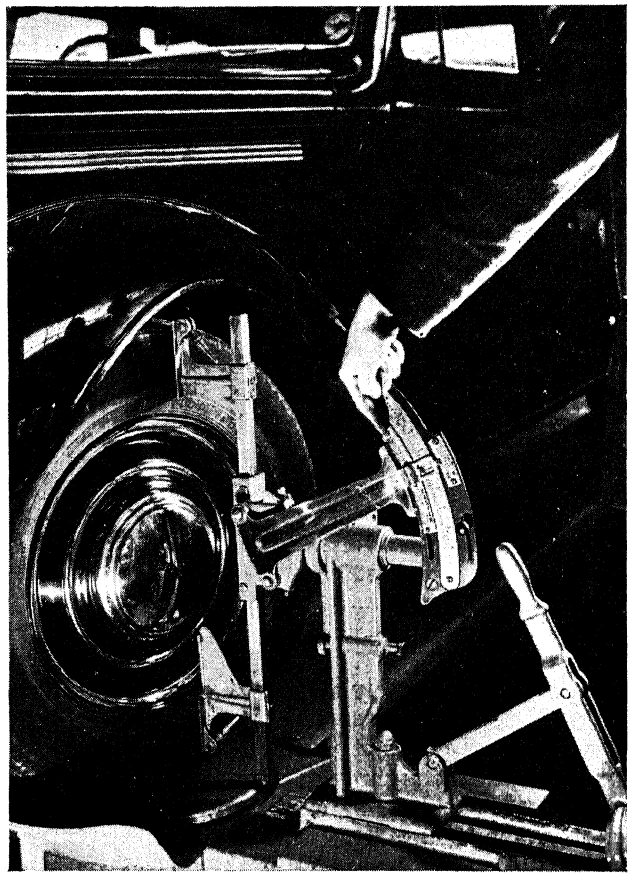


Fig. 13.—CAMBER CHECK
(16-h.p. Snipe and Super Snipe.)

The ball pin for the long track rod is mounted low down on the stub axle, and thus it describes the longest possible arc.

The ideal length of the long track rod would be the radius of this arc, but the slight difference between this radius and the length of the longer track rod is altogether insufficient to introduce any steering reaction, so, by remarkably clever design, extra weight and moving parts which would normally require attention have been eliminated.

The Build-up of the Swivel Pin

The build-up of the swivel pin is as follows :

The knuckle at the top of the pin is secured against a shoulder by the nut. At this point a hardened-steel thrust washer is interposed. On the stub axle itself a similar thrust washer is pegged, and floating between these two hardened-steel surfaces a bronze thrust washer is incorporated. The stub axle itself has two bearings and is bushed in the normal manner. Between these bearings a piece of tubing is fitted which covers the portion of the swivel pins which would be exposed. This tubing is nipped between the swivel pin bushes.

Lubrication

In the screwed bushes considerable clearance is left for the circulation of the lubricant. This clearance is absorbed on the V-threads when

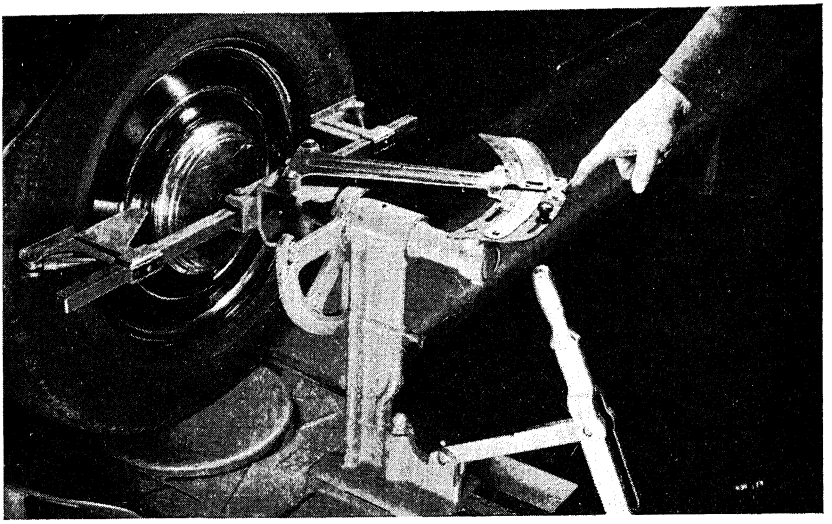


Fig. 14.—TOE-IN CHECK
(16-h.p. Snipe and Super Snipe.)

weight is applied to the bearings, and thus the sloppiness in these which is apparent when they are not under load is no detriment to the action of the bearings in proper use. Owing to this provision, adequate quantities of lubricant are stored in the bearings themselves, which do not require any attention except at intervals of 3,000 miles.

Steering Angles

Given below are the various angles in this assembly, and it should be noted that the wheel camber has a very considerable effect on tyre wear, and this should be checked with great care whenever trouble of this nature is experienced. As has already been explained, the wheel camber varies with the flexing of the front spring, so that before these angles are checked the front spring itself must be loaded to a definite position, which is determined by measuring the spring camber, i.e. the distance between the centre line of the spring eyes and the lower face of the spring at the centre. This distance should be ½ in. Furthermore, as the majority of camber gauges operate on the spirit-level or plumb-bob principle, it is obvious that the car must be level before these gauges can give accurate readings.

Subject to the above remarks, the steering angles are :

Wheel camber	1°
Inclination of swivel pin . .	10°
Castor angle	2° 52′

Position of Ball Pins

If at any time, through accidental damage, the position of the ball pins has been altered, it will be appreciated from the foregoing remarks under the heading of " Track Rod " that this must be corrected accurately if the suspension is to prove satisfactory. The following dimensions determine the correct position of the ball pins :

Off-side Ball Pin on Steering-box Arm with Wheels Straight Ahead

From centre line of spring to centre of ball	123 mm.
From top of frame to centre of ball	236 mm.
From centre line of chassis to centre of ball	9·7 mm.

Ball Pins on Side Steering Arms

Nearside—centre of ball on centre line of spring eye.
Offside—centre of ball 19 mm. above centre line of spring eye.

SPECIAL POINTS TO BE WATCHED WHEN REPAIRING ALVIS CARS

THE PROPELLER SHAFT, REAR AXLE, BRAKES, AND STEERING

By F. C. BROWN

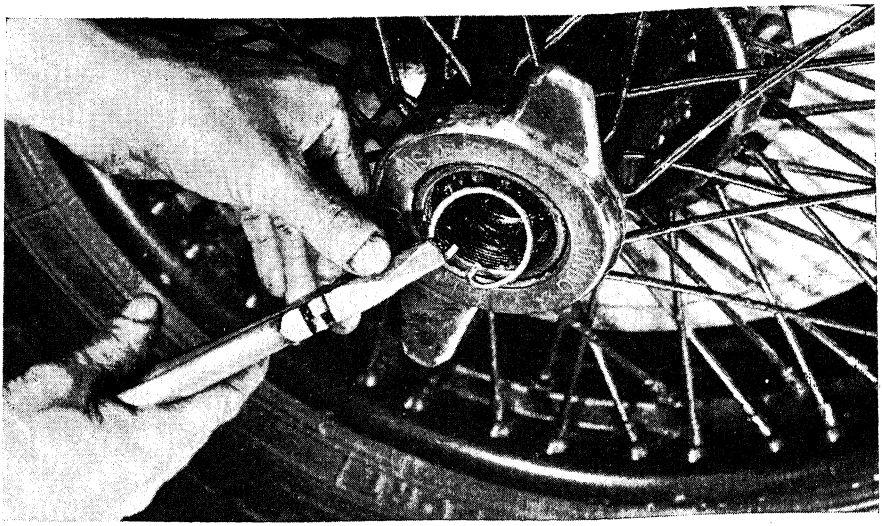


Fig. 1.—REMOVING REAR-AXLE SHAFTS
Extracting spring ring before removing axle shafts.

PROPELLER SHAFT

NO lubrication is called for in the needle roller-bearing propeller shaft joints, but in the event of joint failure it is recommended that the complete shaft with both universals be removed and returned to the works or service depots. A service shaft can be supplied.

Dismantling and Assembling

Should it become necessary to dismantle the propeller-shaft at the front end, there is no need to uncouple the flange bolts. A screw-on collar

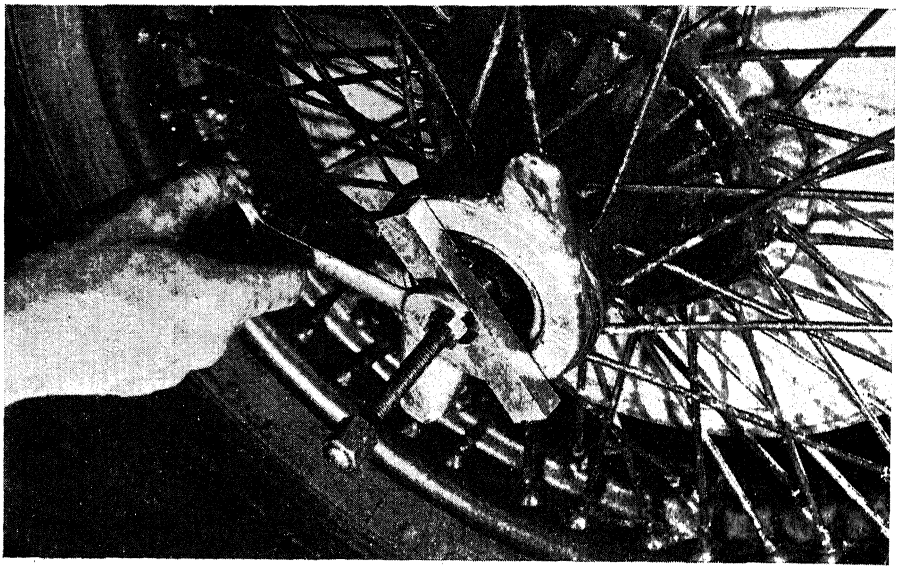


Fig. 2.—REMOVING REAR-AXLE SHAFTS
Positioning rear-axle shaft extractor.

is attached to the front universal joint, and if this collar is unscrewed, provided the shaft is freed at the rear end, it can be pulled clear, leaving the joint attached to the gearbox. When replacing, insert the splined end so that the arrow on the shaft registers with the arrow on the housing.

REAR AXLE

Speed 25, 4·3-litre, and Crested Eagle

The Speed 25, 4·3-litre, and Crested Eagle models have rear axles of the fully floating, spiral-bevel type, the load being taken by steel tubes forced into the aluminium casing under pressure. Dismantling is not complicated, providing the correct sequence of operations is followed.

Excessive Play in Transmission

Before suspecting the differential unit if there is excessive play in the transmission, examine first the clutch-shaft joints, propeller-shaft universal, and wheel driving plates. The latter are corrugated plates on to which the corrugated hub of the road wheel proper is mounted before being secured by the chromium-plated knock-on wheel lockers. It is important that the latter be properly tightened (offside left-hand thread; nearside right-hand thread), but make sure that the splines or corrugations bed firmly. A good coating of thick grease is recommended.

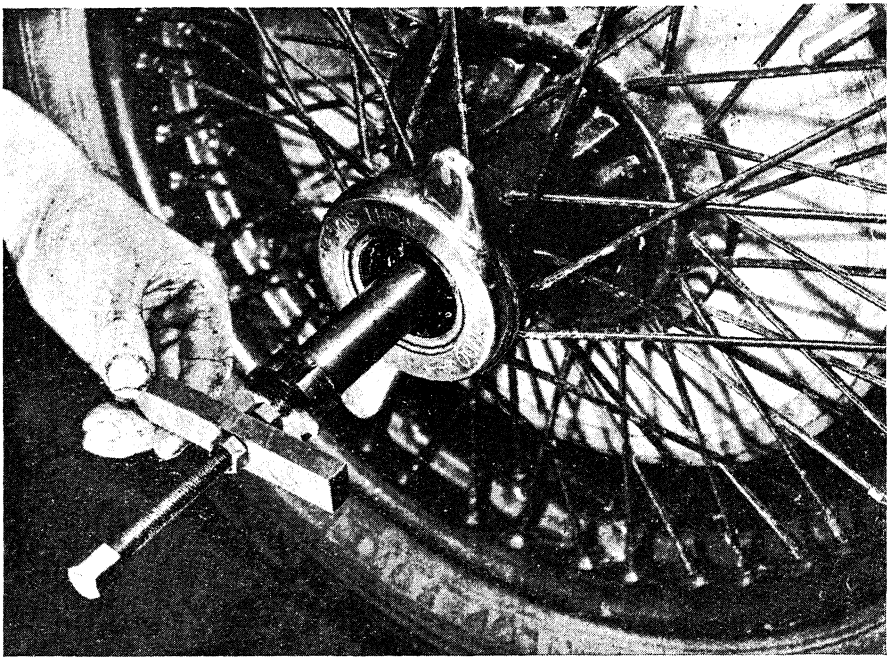


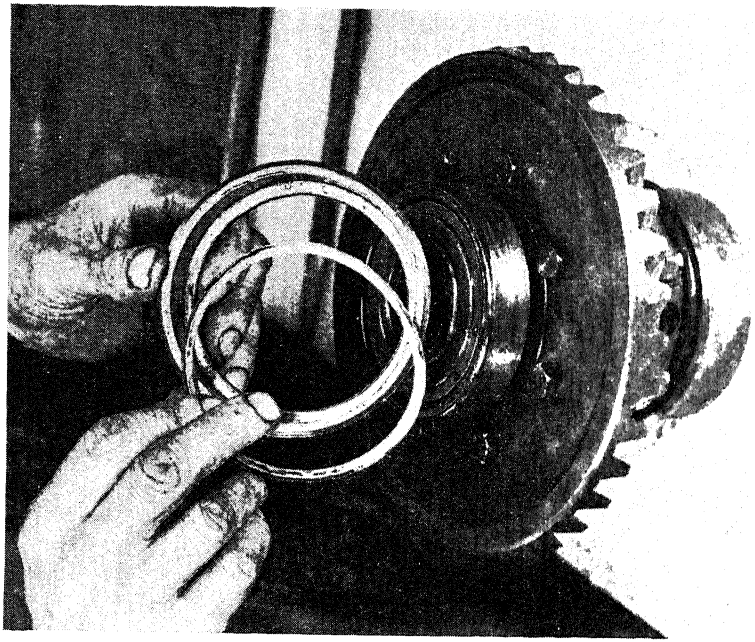
Fig. 3.—REMOVING REAR-AXLE SHAFTS
Withdrawing axle shaft with aid of extractor.

Dismantling Hubs

To dismantle the hubs, first remove the road wheels and take out the grease caps. Next detach the corrugated wheel plate, also the brake drum by extracting the three countersunk screws. Note that the driving studs do not retain the brake drum, which slides off them. The judicious use of a hide hammer may be necessary if the drums have not previously been disturbed. Now the brake shoes may be removed by taking out the spit pins securing the shoe pivot pins ; next the hub cover, which holds the inner bearings ; and finally the hub itself, with the aid of a suitable extractor. This should leave the ball bearing and inner race of the roller bearing on the axle tube.

It is necessary, when reassembling, to ensure that the nut holding the hub bearings on the extension of the axle tube is securely locked in position. Watch also the offside parts with left-hand threads—hubs, grease caps, etc.

In all cases it is necessary to withdraw the axle shafts before the differential can be extracted, and in the case of the 12/70 this means complete hub assembly also. On all other models, however, the removal of the road wheels and grease caps reveals the ends of the axle shafts,





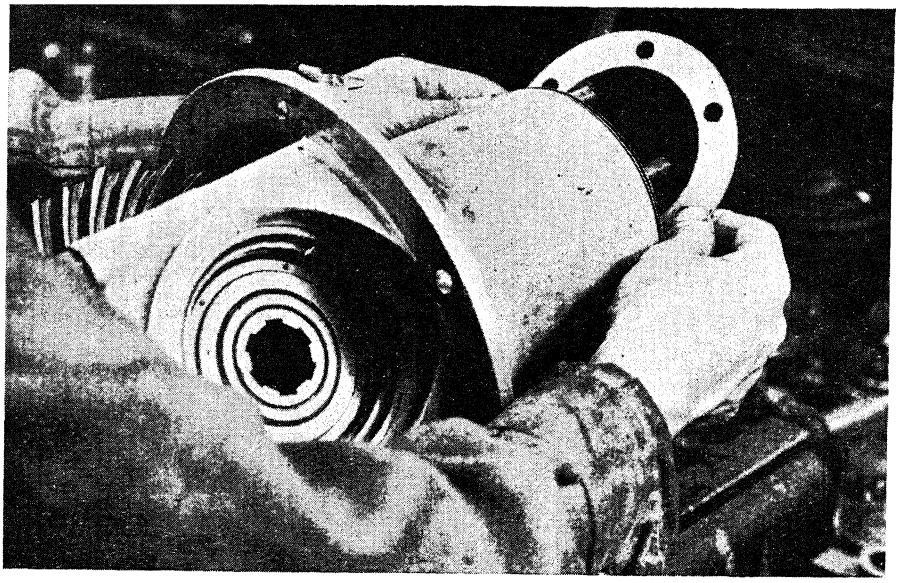


Fig. 5.—REAR AXLE
Sideways adjustment of crown wheel, using brass shims.

Fig. 6.—REAR AXLE
Shimming bevel pinion to correct fore and aft play.

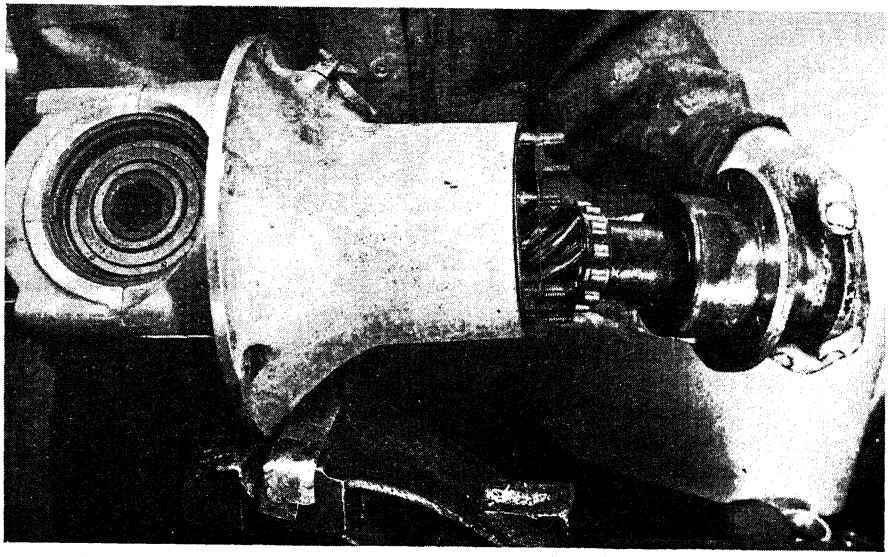


Fig. 4.—REAR AXLE
Sideways adjustment of crown wheel, showing brass shims.

Fig. 7.—REAR AXLE
Reassembling bevel pinion assembly.

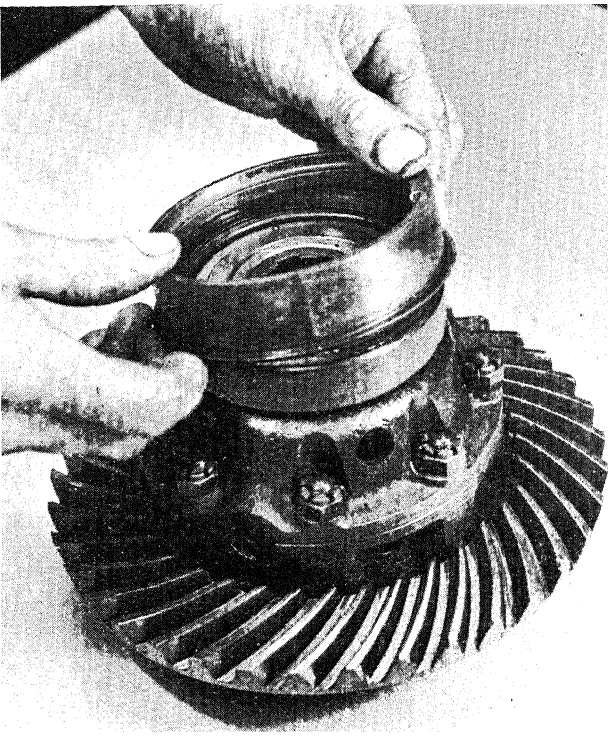


Fig. 8.—REAR AXLE
Removing differential bearing housing.

which are drilled and tapped to take a suitable extracting bolt. The replacement of these shafts requires care. They should be turned slightly so that the splines register with the differential sun wheel—a few taps with a hide mallet is all that is required.

Do not Interchange Axle Shafts

Axle shafts are marked right-hand and left-hand, and must not be interchanged, as they have oil-retaining scrolls machined in them, and reversing the shafts means that oil will be guided from the differential instead of back to it. This does not apply to the 12/70 and Silver Crest types, but it is not recommended that the shafts be changed over unnecessarily.

Rear Hubs on Silver Crest

For the Silver Crest series hub dismantling is carried out as follows :

(1) Remove the road wheels.

(2) Disengage the tab washers and remove the hub grease caps.

(3) Extract the three countersunk screws and remove the brake drum.

(4) Remove the five wheel-stud nuts. They are to be found at the back of the hubs.

(5) Affix cover-plate extractor to the hub by means of the tapped holes provided and extract the hub, exposing the bearings.

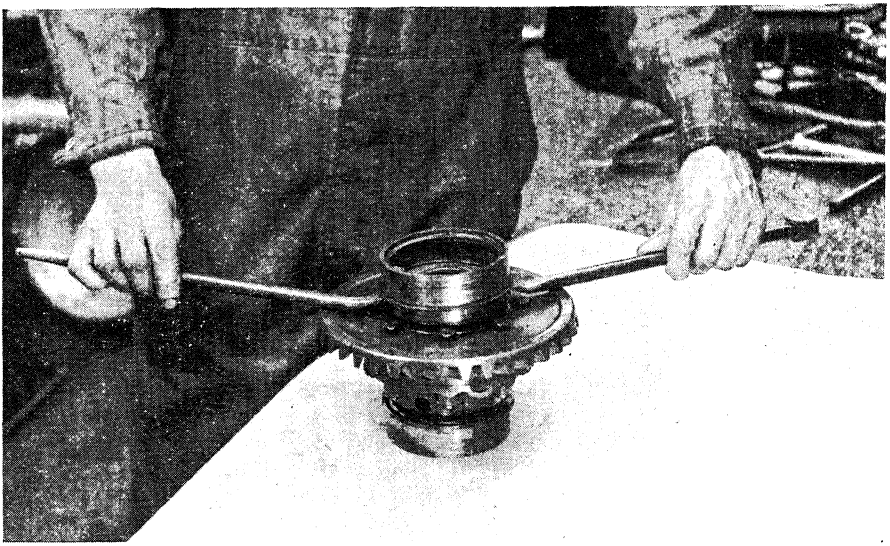


Fig. 9.—REAR AXLE
Extracting ball race from differential assembly.

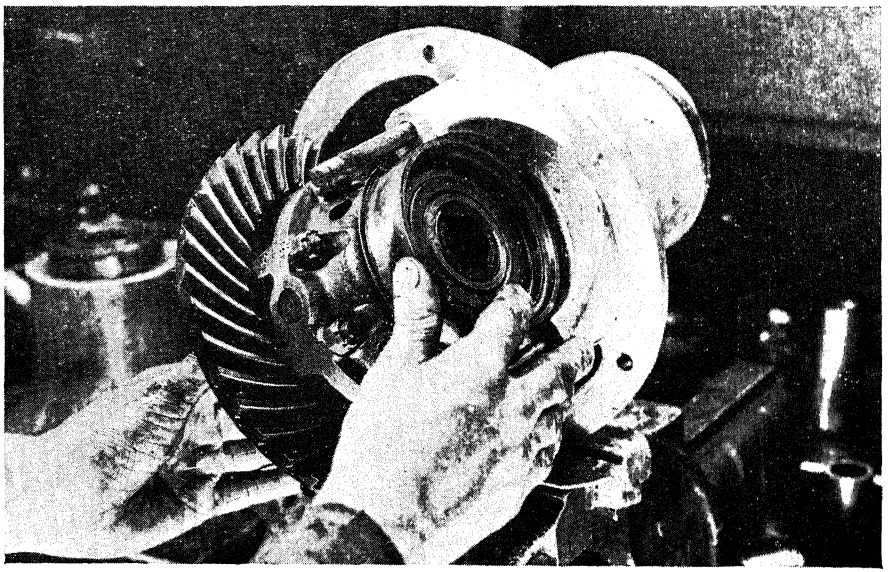


Fig. 10.—REAR AXLE
Replacing differential unit in differential housing.

Differential Units on All Models

To replace all differential units proceed as follows :

(*a*) Remove axle shafts.

(*b*) Lower the rear end of the propeller shaft by undoing the bolts which hold the universal joint to the bevel-pinion flange.

(*c*) Unscrew the nuts holding the front housing to the main axle casing.

(*d*) Withdraw the housing, together with the pinion and differential gear.

A receptacle should be available to catch the oil from the axle casing.

Adjustments fore and aft and sideways to the meshing of the pinion and crown wheel are made by means of brass shims of various thicknesses.

A point to note in respect of the 12/70 is that excessive end float on the rear-axle shafts may be taken up by removing the shims between the wheel-bearing housing and the brake carrier plate, but the hub and brake drum must first be extracted. When reassembling see that the shafts still have *some* end float. Between ·003 in. and ·006 in. is ideal.

Another note regarding the 12/70 might usefully be inserted here. Adequate lubrication of the *front* hub assemblies is really important. Cases have been brought to light where shortage has caused bearing failure. To prevent this, fully charge the hubs with grease, not oil, when assembling, and give a smaller charge at intervals of 5,000 miles. Should bearing failure have occurred from dryness, examine also the stub axle to see if there are traces of scoring or if the stub is out of truth. Replace if the slightest doubt exists about its condition.

BRAKES

Adjusting Brakes on 4·3-litre, Speed 25, and Crested Eagle

Although the wing adjusting nuts on the 4·3-litre, Speed 25, and Crested Eagle systems are useful in enabling quick and easy adjustment to be made generally, compensation between front and rear and balance between nearside and offside brakes can only be caused by individual adjustment on each of the four brake cables. This adjustment, which is necessary at regular intervals, is made as follows :

(1) Jack up the car with all four wheels clear of the ground.

(2) Slacken off the central wing-nut adjusters to the fullest possible extent.

(3) Recentre the front brake shoes by turning the eccentric stops in the front brake cover plate. These will be found immediately above the steering pivot. These stops are fitted with a pointer which moves in between two lines marked "off" and "on." The stops should be slackened back until the wheels just spin freely without the shoes touching the drum.

(4) Pull on the hand brake lever one notch.

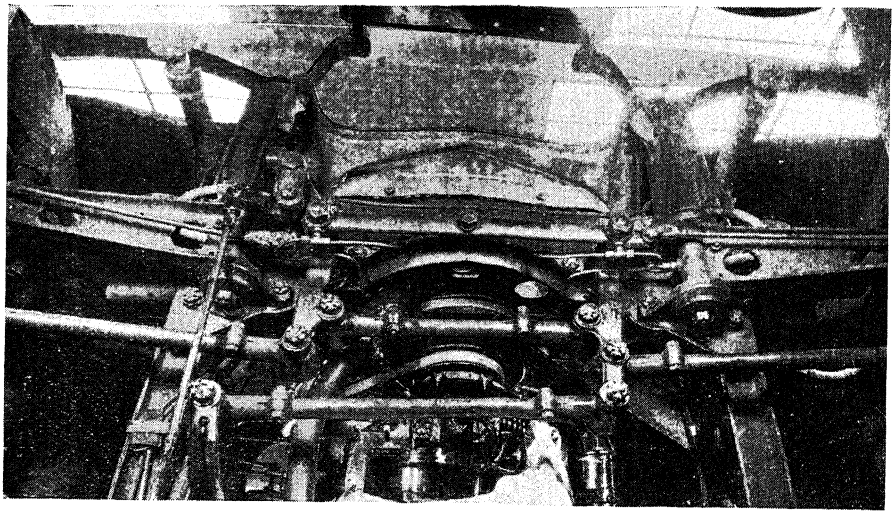


Fig. 11.—STEERING-ROD LAYOUT
View from underneath Silver Crest.

(5) The two front brake-cable adjusters are now unscrewed until the front brake shoes just grip the drum, so that a little effort is necessary in order to turn the wheel. The locking nuts will, of course, have to be slackened off before the adjusters can be manipulated, and should be resecured on completion of the adjustment.

(6) Pull on the hand brake lever two more notches.

(7) Recentre the rear brake shoes as for the front.

(8) Adjust both rear brake cables as for the front by means of the nuts provided on the cable extremities.

(9) With all brakes off ensure that the wheels are free to rotate with no brake shoes rubbing.

Servo Assisted Brakes

Latest Speed 25 and 4·3-litre models have Alvis brakes servo assisted. Note that the pull rod of the servo motor should be adjusted until the pedal head tends to be drawn away from the floorboard. The valve has two definite motions which can be felt by hand, one to take up clearance and close air port, the other to open vacuum port. The valve should be adjusted so that there is about $\frac{3}{32}$ in. to move out of the total $\frac{1}{4}$ in. available before the vacuum valve opens.

Flexible gaiters on both servo and valve unit must not be damaged, as ingress of dirt must be prevented if the vacuum brake is to function satisfactorily.

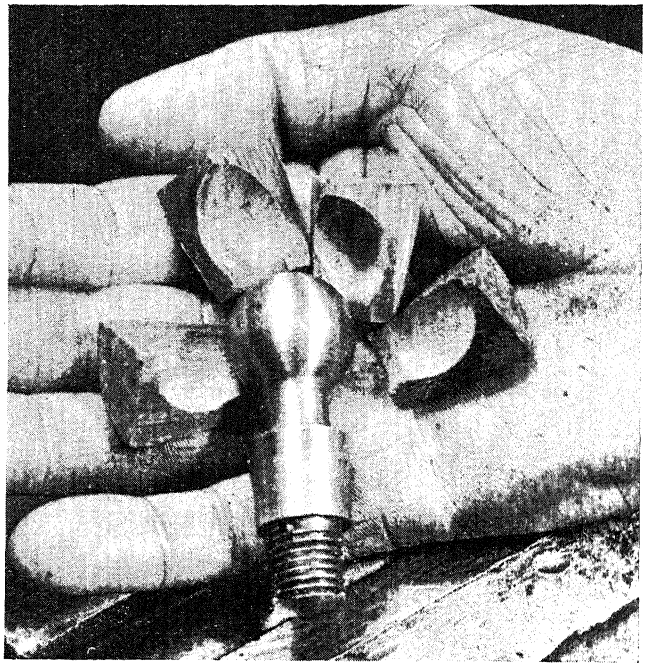


Fig. 12.—WEARING PARTS OF STEERING JOINT
Showing the steel ball pin and split lignum vitæ bearing.

Bendix Brakes

On the 12/70 and Silver Crest models Bendix brakes are standard, and providing the brake-operating mechanism works freely the only adjustment necessary is as follows: Screw up the shoe adjuster until tight, by rotating in a clockwise direction, and then slack back three-quarters of a turn, that is, five notches or clicks.

It will be observed that there is no central adjuster, and adjustments must be made at the individual drums. When brakes need relining, apply to the Works for genuine Bendix replacement shoes (this does not apply to Alvis brakes, as with them it is recommended that the original shoes be relined with standard die-pressed linings obtainable from the works or service depots). A further note regarding Bendix brakes—do not interfere with the operating mechanism by shortening the rods or cables, but do keep the compensators working freely by spraying with oil occasionally, and grease the working parts well with graphite grease.

Braking Noises

When in new condition Alvis brakes have a tendency when applied to shriek, which terminates in a groan as the car is brought to a standstill. Although the noise is harmless and will eventually wear off, it can be eliminated by filing the friction surfaces of the linings at each end to form a chamfer of about $\frac{3}{4}$ in. In addition, the sides of the linings should be filed to obtain a pointed effect.

STEERING

Adjustment of Marles Steering

All models with the exception of the Silver Crest range are fitted with Marles steering, there being generally two adjustments—between



Fig. 13.—THE FIRST STAGE IN ASSEMBLING STEERING-ROD JOINT

the roller and cam; and of the bearings between which the cam revolves. It is, of course, necessary to remove the steering unit from the chassis.

It will be noted that the roller is mounted on an eccentric bush or distance-piece which is carried by a bolt and nut. The latter has its centre part serrated, being a fit in the serrated hole in the rocker shaft farthest away from the head of the bolt. By means of these serrations, therefore, the bolt ties together the positions of the distance-piece and rocker shaft. As the distance-piece is made with the outside diameter eccentric, the roller assembly (mounted on the distance-piece) moves in relation to the rocker shaft by rotating the bolt, and in this manner the roller assembly can be raised or lowered away from the cam. After the rocker shaft nut and washer have been removed the rocker-shaft bolt should be withdrawn until the serrations are just free of the rocker-shaft serrated hole—that is, about $\frac{3}{8}$ in. Turn the bolt one or two serrations in a clockwise direction for giving deeper engagement between roller and cam.

End play of the cam bearings may be taken up by removing some of the thin shims between the box casting and the column support. The shims between the casting and the bottom plate should on no account be taken



Fig. 14. THE SECOND STAGE IN STEERING-ROD JOINT ASSEMBLY

Inserting spring and adjusting plug.

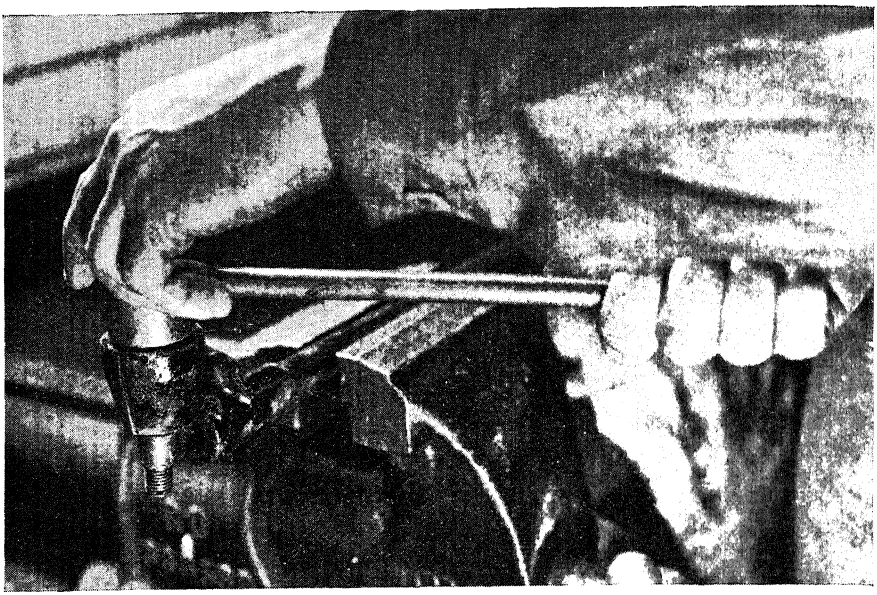


Fig. 15.—REASSEMBLING STEERING JOINT ON TRACK ROD

away. In the case of steering types L. 7 and R. 7 Marles gears there is provided an adjusting screw to take up excessive end play in the rocker shaft. It is merely necessary to release a locknut to gain access to the adjusting nut.

Burman Douglas Steering

The only adjustment recommended on the Burman Douglas type of steering used on the Silver Crest cars is a slight tightening of the ball race at the top of the column, and then only after a long period of service when the balls may have buried themselves in the track of the races.

Checking Up Self-adjustable Steering Joints

Every car has self-adjustable steering joints of the split conical lignum vitæ bush type. They should be checked for tightness periodically, and the wood bearings renewed if necessary. On older cars carefully examine the ball pins also, and remember that on the cars having independent front-wheel suspension there are *eight* separate ball-joint assemblies which require attention.

Wheel Wobble

Should trouble with wheel wobble or tramp occur, check first the condition of these lignum vitæ steering joints, then the tracking of the front wheels. On the Silver Crest and 12/70 models they should be set

to toe-in approximately $\frac{1}{8}$ in., but the Speed 25, 4·3-litre, and Crested Eagle models must have the wheels set to toe-out between $\frac{1}{8}$ in. and $\frac{3}{16}$ in. Watch also the tyre pressures, and replace worn outer covers.

If the difficulty persists, attend to the balancing of the front wheels; changing the nearside to offside or front to rear may give the desired result on the Silver Crest or 12/70 cars. On the larger models, wheel balance has been found to have a real bearing on wheel wobble, and wheel balance-weights, consisting of a number of flat balance-weights bolted inside cups to the inside of the wheel rims, are fitted as standard. The procedure for rebalancing is as follows:

(1) Jack up the front of the car, and ensure that the brakes are free.

(2) Test to see if there is a tendency for the wheel always to revolve so that a heavy portion falls to the six-o'clock position.

(3) If this does occur, remove the cup from the balance-weight assembly which is nearest diametrically opposite to the heavy portion of the wheel, and add a weight or weights to restore balance.

(4) Repeat the process until perfect balance is obtained. It may, of course, be necessary to completely reweight the three assemblies to effect this.

These cars are also provided with a front harmonic stabilising bumper, and if all other efforts to eliminate wheel wobble or tramp fail, variation of the weights in the end-cap assemblies should be tried. Usually heavier chromium-plated weights will do much to help, and suitable ones can be obtained. It must be made clear, however, that the bumper must not be interfered with in the ordinary way and certainly not until all the points already mentioned under "Steering" have been covered.

A final point regarding Marles steering units. Should a new cam-roller assembly be fitted on the L. 7 steerings, the replacement will probably be of a modified pattern although strictly interchangeable. It is important to see that the new cage is assembled correctly, and to do this the cage assembly should be fitted on to the coned inner race on the cam, and then the outer race assembly over them. The cage assembly should not be assembled with the outer race.

Shock Absorbers

Silver Crest and 12/70 models have ordinary Luvax hydraulic shock absorbers, for which internal adjustment is provided. Remove the filler plug and turn adjuster in a clockwise direction to tighten. The 4·3-litre and Speed 25 cars are fitted with finger-tip control mechanism. The over-riding control is provided by a spill valve situated on the engine side of the dash, and which enables the pressure generated by the independent pump to be discharged into a reservoir at varying rates depending on the position of the spill valve, which has a graduated rate of discharge into the reservoir, controlled by the lever on the dashboard.

These shock absorbers are often abused. When the car is heavily loaded and at high speeds the control must be turned to maximum, or the springs, which are designed to give the best comfort at all speeds, will have to do more than their share of work and bottoming may result. Otherwise the shock absorbers need little attention save the refilling of the absorbers themselves with official Luvax fluid (this applies to all Luvax shock absorbers). Topping up to a maximum high level of $\frac{3}{8}$ in. from the top at intervals of 8,000 and 10,000 miles is all that is necessary. In the spill-valve reservoir a winter grade of engine oil should be used—not the shock-absorber fluid.

Should there be a tendency for the front shock-absorber bolts on the 1938, Speed 25, and 4·3-litre cars to work loose, apply to the works for a supply of special nickel-chrome bolts, and refit to the frame. With the new bolts a plain washer should be fitted under the bolt head on the inside of the chassis number, and the nut should be split-pinned after tightening hard.

12·70 Rear Springs

When carrying out replacements of 12/70 rear springs it is necessary to remove the metal cover from the body valance. This cover is secured by six wood screws, and when it is removed the wooden valance will be found to contain a large aperture, through which a box spanner can be inserted, and the rear-spring front shackle pin removed. It is often thought necessary to remove the whole shackle bracket, but if the foregoing procedure is adopted this will not be necessary.

Roof Rear Drain Tubes

These tubes are carried from the rear of the roofs down through the rear quarters and protrude through the rear-wheel arches. In some cases the rubber tubings are left a little too long so that they foul the tyres when the car rolls or is heavily laden. The resulting noise can be very alarming—something between a loud roar and a screech, but a remedy is easily effected by cutting off the rubber tubes by about 2 in., which will give ample clearance. It is a simple point, but one might search a long way without being able to locate the cause.

Windscreen Water Leaks

If rain should leak in behind the windscreen rubber it is liable to pile up at the bottom and work through the wiper mechanism or the windscreen fillet. By punching or drilling one hole on either side of the screen rubber at the bottom corners, any trapped water will be released and drained away. The holes should be approximately $\frac{3}{32}$ in. in diameter and $\frac{1}{4}$ in. from the outside edge of the rubber. They must, of course, be positioned at the lowest points on either side of the windscreen.

CHASSIS LUBRICATION

Some Alvis chassis have incorporated an automatic lubrication system operated by the action of the clutch pedal. A pump is mounted on the engine sump from which it obtains its oil-supply.

The only adjustment which is likely to need the attention of the repairer is that for increasing or decreasing the supply from the pump. There are two outlets and two adjusters on the pump, and once it is decided which series of points requires attention the appropriate adjuster may be turned in an anti-clockwise direction to decrease the rate of flow, and vice versa. One and a half turns will reduce the rate of flow by approximately one-half, but care must be taken to see that all the points fed by the system are receiving adequate lubrication.

It is important to check up on any central lubrication system at periods of approximately one month, and if oil is not reaching any particular point or points, these should be dealt with before damage is done to the respective parts. It is not good engineering to leave a centrally lubricated bearing alone until it starts to squeak—preventive service is an important matter. Cars which are pressure-washed very frequently are liable to get water and mud forced in through such parts as king pins and shackle pins. When a car is so washed frequently, extra central lubrication should be the rule.

SERVICING CHEVROLET CARS

FRONT-WHEEL SUSPENSION AND BRAKES

By N. A. MOORE

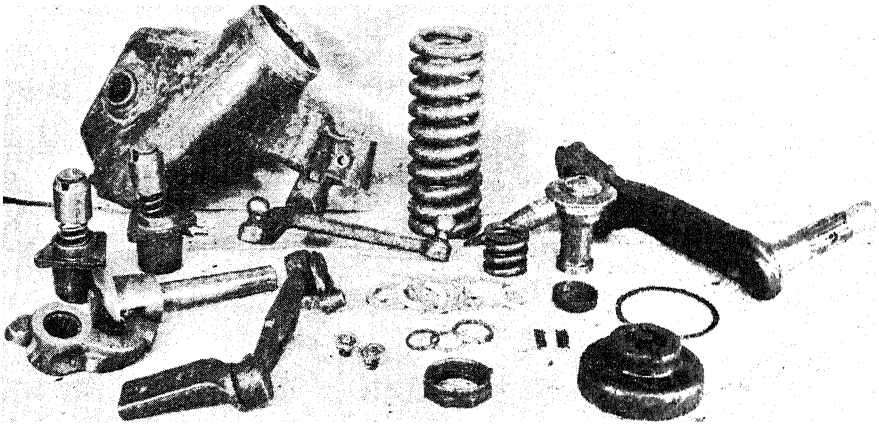


Fig. 1.—PARTS OF CHEVROLET KNEE-ACTION ASSEMBLY

KNEE-ACTION UNITS

Maintenance

THE fluid levels in these units should be checked every 750 miles, and the correct amount of fluid added to bring the level up and even with the square filler plug which will be found on the front of the housing. Only the correct fluid is to be used in this instance, which will be Wakefield Shockol. Most Chevrolet dealers stock this fluid.

Lubricating nipples should be regularly run over to ensure that all working parts are thoroughly greased to reduce friction and prevent wear, and particularly radius-arm nipples, to expel any water that may have penetrated into the working thread ends. This operation must be carried out with a hand grease-gun. High-pressure lubrication will blow out swaged plugs on radius arms.

In checking the knee-action unit, the car should be jacked up, and suitable jacks placed under the king-pin carrier for safety. The front wheels can then be taken off and drums removed. This will allow a proper check to be made for wear on the brake carrier flange bushings.

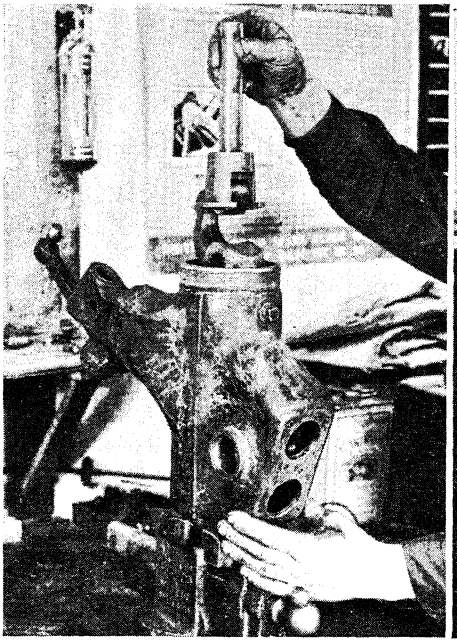


Fig. 2.—REASSEMBLING KNEE-ACTION UNIT
Fixing knee-action main spring into position.



Fig. 3.—REASSEMBLING KNEE-ACTION UNIT
Wheel-bearing spindle going into position. Note the needles held together by means of an elastic band.

If worn, they should be replaced. It is important that the inner and outer wheel bearings be kept free from grit, and before replacing they should be thoroughly washed.

Careful check should be made of all ball and socket joints, steering-arm nuts, and king-pin support bolts on the chassis frame.

The steering gear also should be checked at the same time to see that the adjustments are correct.

Knee-action Repair

In order to check the height of the knee-action unit, the measurement should be taken from the bottom of the king-pin support to the bottom of the brake flange plate. This measurement should be $4\frac{7}{8}$ in., plus or minus $\frac{1}{8}$ in., and both sides should be equal within $\frac{1}{4}$ in. If this dimension is found to be incorrect, remove the setscrew retaining lockplate; the inner plug is then to be wound down to increase height of the car, or released to reduce height of car. In doing this, a margin of safety is to be observed. This plug should not be wound down to show more than three threads of the outer cap.



Fig. 8.—ASSEMBLING KNEE-ACTION UNIT
Fitting main spring guide into position.



Fig. 9.—PUTTING MAIN SPRING CAP AND ADJUSTER IN POSITION
Tension of spring can be adjusted by means of screw at top.

necessary to renew the complete unit; there are several component parts, comprising housing and cap, inner spring, upper spring assembly, spring guide, adjusting plug, complete shock-absorber units or component parts.

Remove the $\frac{5}{16}$-in. setscrew from the adjusting plug on the top of knee-action unit, and screw out the main spring adjusting plug. This relieves the tension on the main spring centre guide and allows safe removal of the housing cover.

Remove the housing cover, then lift the main spring upper seat assembly out from the housing. Lift out the large outer spring. If a spacer is found under this spring, it must be replaced if the old spring is used when reassembling, but if a new spring is installed, discard the spacer. Remove the inner rebound spring from the lower spring seat at the bottom of the housing, empty out the shock insulation fluid into a clean pail or can; loosen shock-absorber cap screws.

Care should be taken when removing shock-absorber units, as each unit contains a strong valve-retaining spring. The wheel support arm

shaft cannot be withdrawn until compression and rebound units have been removed. Then will be seen the cheese-headed locking screw. To remove this screw, a heavy screwdriver is required. When screw is extracted, the next operation is to loosen locking grub-screw on gland nut. Then with the special gland-nut spanner undo the nut until it clears the threaded boss on knee-action body. It will be noticed that while undoing the nut, the nut will be with drawing shaft. With one hand under the gland nut, withdraw shaft and catch needle-roller bearings.

New parts can be fitted, and the above operation can be reversed for reassembly.

After assembling the unit, it is advisable to bounce the car up and down several times before taking the measurements stated in the early paragraph of this article, and also the radius-rod brackets should be allowed to take up their best position before locking in place, after which the two ¾-in. S.A.E. setscrews should be securely tightened and locked with the locking plate. Then give the car a good road test, for preference over rough roads, to check the action of the front wheels and also to get the fluid circulating through the shock absorbers to expel all air. After testing the car, examine the radius-rod brackets and see that they are thoroughly secure.

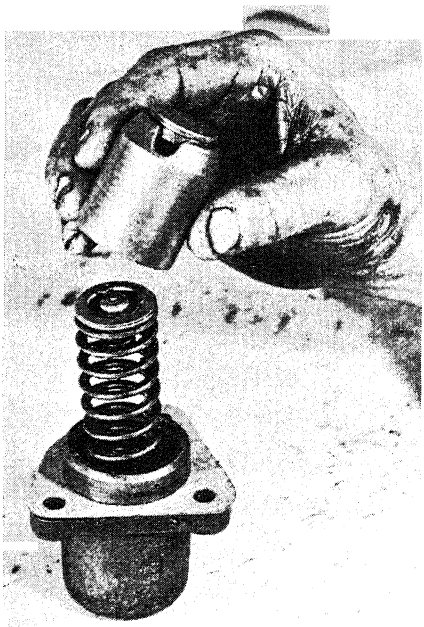


Fig. 10.—ASSEMBLY OF SHOCKER AND VALVE

To Remove Knee-action Units

To remove or replace knee-action units, proceed as follows : Jack up car on suitable jacks, remove front wheel and drum. Disconnect radius arm, by removing the two ¾-in. S.A.E. setscrews, on the bottom of knee-action body, and remove lockplate. Disconnect radius arm, turn the unit outwards on full steering lock, and remove brake-carrier assembly, taking care not to twist or damage rubber brake-fluid pipe. Place this assembly on a suitable wooden block to take the weight off the rubber connecting pipe. Next remove the cotter, locating the king pin. Remove the dust cover, to be found on top of the king-pin support yokes. Remove the spring-retaining rings on the top and bottom of king-pin yokes. Then drill a ¼-in. diameter hole through top plug. Insert a

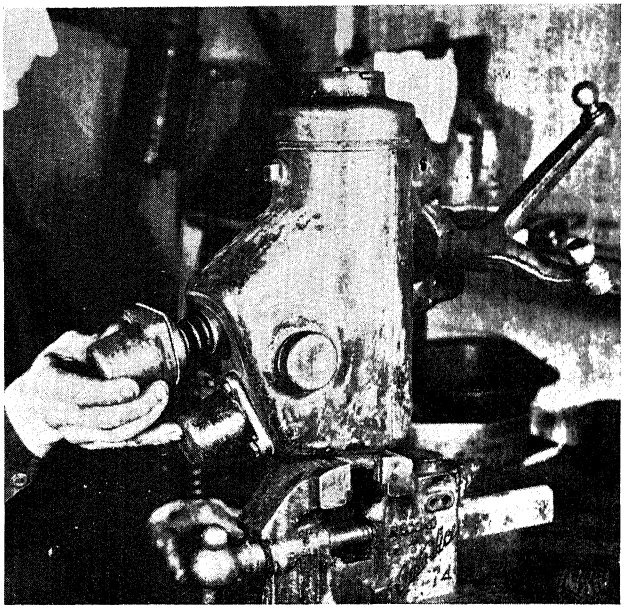


Fig. 11.—ASSEMBLING KNEE-ACTION UNIT
Fitting shockers into body.

drift and drive out bottom plug. Reverse the action and drive out top plug. Now drive the king pin out of support bearings, and carefully remove knee-action units, taking care not to damage the thrust race. Look out for any shims that may be found on thrust race. Now remove the top and bottom floating king-pin bushings, and check for wear.

Whilst these parts are dismantled, carefully check the bores in the king-pin support yokes. Should these be found loose, it is advisable to fit over-sized bushes. A special reamer is supplied for this purpose, and is available from Chevrolet stockists.

A careful note must be made that the reamer is not forced, and the reamer should be liberally lubricated, and rather allowed to feed by its own weight.

The lower yoke can be reamed in the same manner as the upper unit, but the over-size pilot sleeve must be used in this instance.

Reassembling the Knee-action Unit

To reassemble the knee-action unit to the king-pin support the following operations are necessary: Start inserting the king pin at the bottom, being sure that the longest end of the king pin from the slot is at the top, and that the slot in the king pin lines up with the lockpin hole.

Tap the king-pin thrust bearing into place, using a soft lead hammer. The king-pin thrust bearing must be assembled between the upper support boss and the top of the spring housing or steering knuckle; make sure that the dust-shield side is towards the top.

Check the end play between the spring housing or steering knuckle with a feeler gauge, and if this is over ·006 in., insert a steel shim of the correct dimensions to overcome.

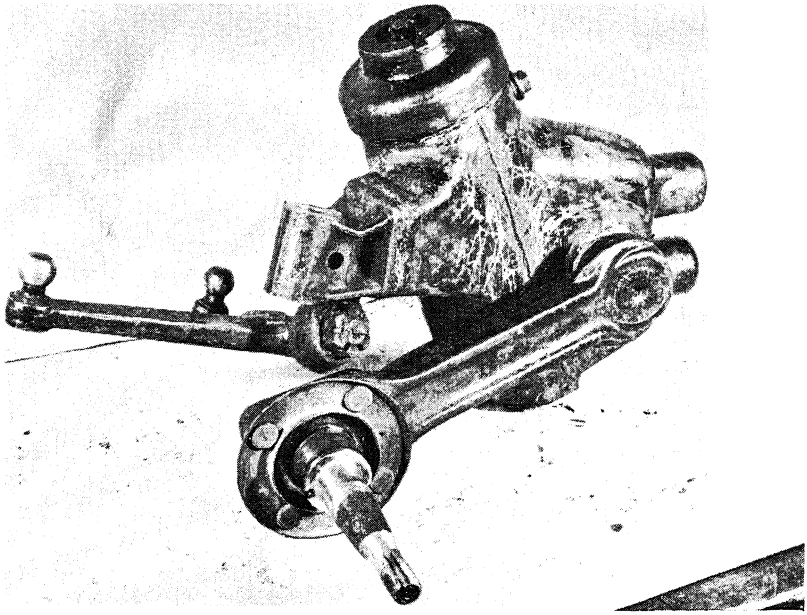


Fig. 12.—COMPLETED KNEE-ACTION UNIT

Assemble the brake flange plate to the wheel-carrier spindle, smear the cork gasket with heavy oil or grease and install on the spindle ; assemble the bearing spacer to the brake flange plate, so that the tongue on the spacer engages the slot in the spindle, and assemble the inner bearing cone. Fit the front wheel to the spindle and reassemble in the usual manner. Great care should be taken in connecting the radius rod to the knee-action housing. Screw the radius-rod bracket up tight on the radius rod. Then bring the radius rod straight up without moving it to either side. Loosen the bracket just sufficiently to line up with the boss on the front-spring housing. Then place in position on the boss and assemble the lockplate and tighten the two radius-rod brackets to the housing bolts securely.

Place the knee-action body in the vice, using the block on the bottom of housing as a means of holding. Care should be taken that the unit is clean, and that the bearings for the needle rollers are not damaged in any way.

The gland-nut bearing on the wheel support spindle arm should be checked for any step wear, due to the action of the arm. This should be dressed up with a smooth flat file with a safety edge.

Coming to the installing of the gland packings : first, insert gland rubber to gland nut, and then lightly smear gland cork with grease, and place on top of gland rubber. Next place taper spacer into gland boss

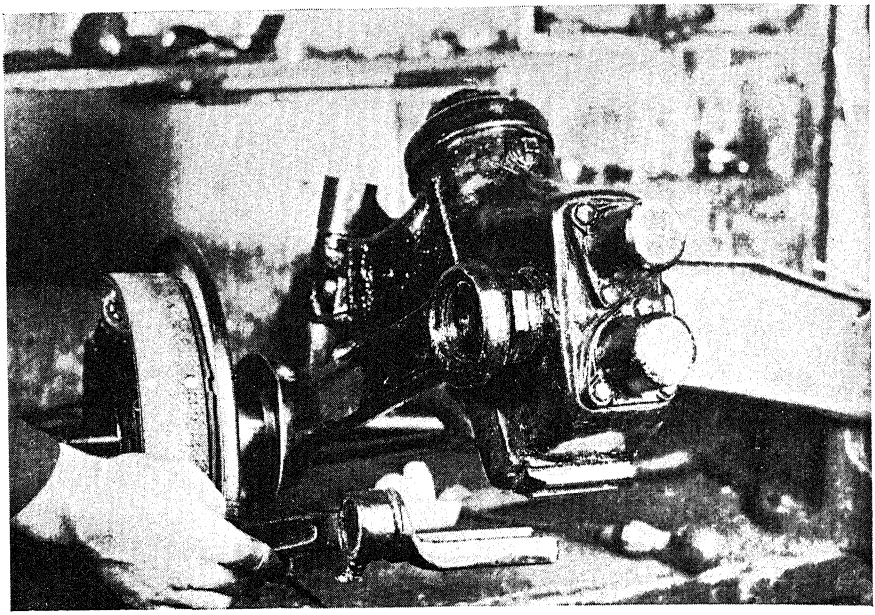


Fig. 13.—FITTING BRAKE SHOES AND LININGS TO KNEE-ACTION UNIT

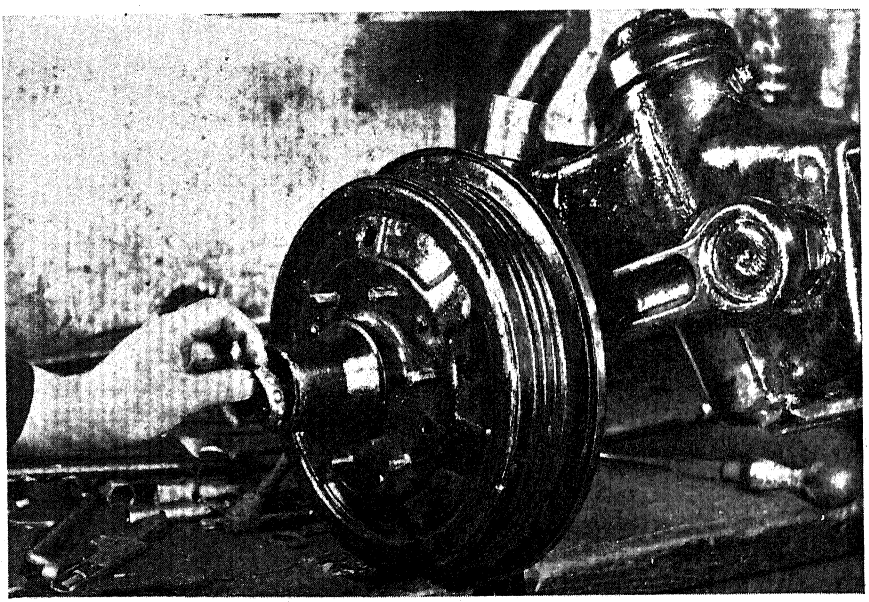


Fig. 14.—PUTTING IN BALL RACE AFTER FIXING BRAKE DRUM

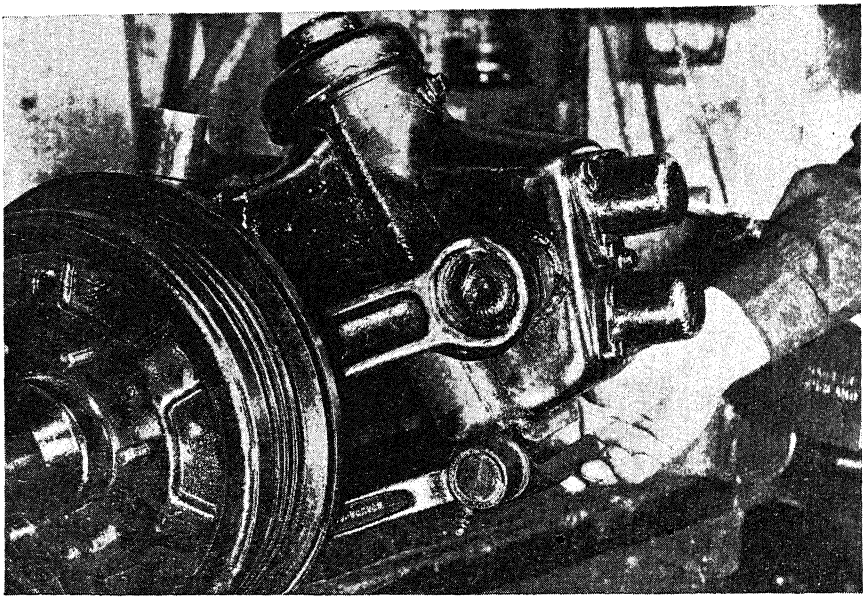


Fig. 15.—FIXING RADIUS ARM TO KNEE-ACTION UNIT

on knee-action body and screw on gland nut three to four threads. The next operation is to enter the wheel support spindle arm through the gland nut into the body, and by working arm up and down with some pressure, it will be found that the gland spigot on the arm will have entered nut and packings. Next unscrew arm and nut at the same time and withdraw wheel support spindle arm, and it will be found that the rubber and cork packings with the taper spacer will be in position.

Into the bearing on the gland side of body enter the needle-roller spacer, that is the $\frac{1}{4}$-in. broad spacer, and push through to the inside of bearing. Then into the bearing on the other side of body place another spacer and push through to inside. Now place main spring centre guide into knee-action body.

The needle rollers should now be placed around bearing on wheel support spindle arm ; these may be held in position by means of a small rubber band.

Now enter wheel support spindle arm ; care should be taken to line up correct spline so that cheese-headed locating screw can be entered first time. The gland nut should be taken up until wheel support spindle arm falls with its own weight. When gland nut is in position, grub-screw should then be tightened. The remaining needle rollers can now be inserted into the other bearing, and the special spacer placed in position. A new cork gasket should be put into the cap and a suitable sealing

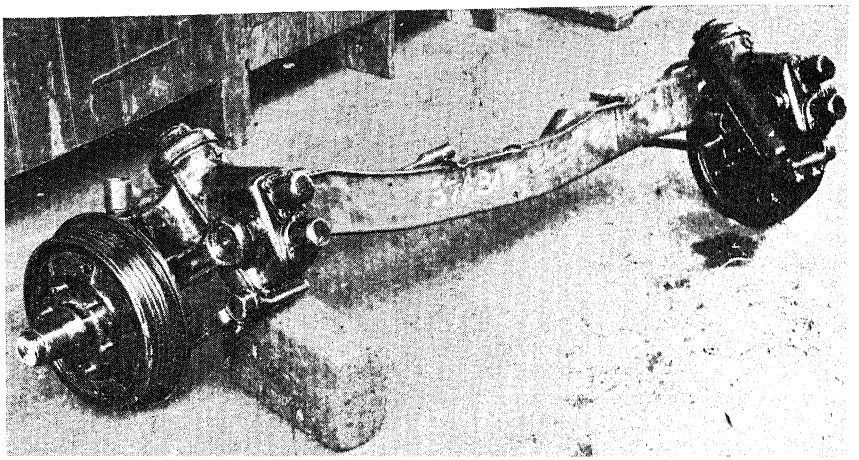


Fig. 16.—COMPLETE FRONT AXLE AND KNEE-ACTION SUSPENSION ON 1938 CHEVROLET

preparation smeared on the cork ; now lightly tap cap into position with a hammer.

The compression and rebound units may now be assembled with new gaskets, and should be tightened down equally.

Fill the knee-action unit with the correct fluid, as previously stated.

Remove the plug from the back of the front-wheel spindle and fill the reservoir with petroleum jelly.

Recheck knee-action heights to ensure the correct dimensions from the bottom of the king-pin boss to the bottom of the brake flange plate, as before mentioned.

It is advisable, after all knee-action overhauls, to check the front wheel track. This should be toe-in $\frac{1}{8}$ in. maximum. The track rod is adjustable by means of a right- and left-hand threaded tie-rod. After setting tie-rod, lock by tightening U-clamps on each end of tie-rod.

FRONT-WHEEL SUSPENSION OF 1939 MASTER DE LUXE CHEVROLET

Chassis coil springs are employed on these models and are mounted in seats, one seat attached to the lower control arms and the other in the frame front cross member.

The front and rear upper control arms are permanently attached to the shock-absorber shaft, to provide great strength and resistance to shock. This is controlled by double-acting shock absorbers of the end-to-end discharge type, which are rigidly bolted to the top of the frame front cross member.

The two upper arms of the shock absorber are electrically welded together.

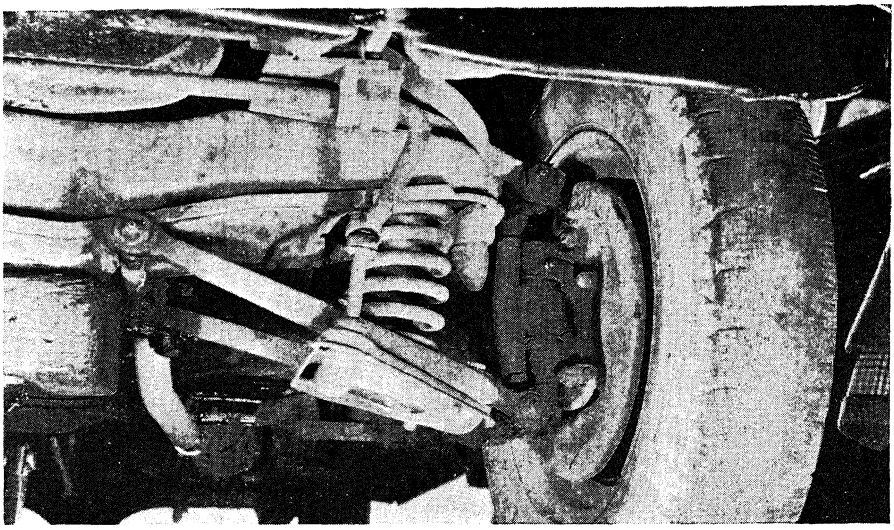


Fig. 17.—FRONT-WHEEL SUSPENSION OF 1939 MASTER DE LUXE CHEVROLET
Note greasing points.

The steering-knuckle support, which carries the steering knuckle and king pin, is pivoted at each end (upper and lower) to the corresponding control arms. At the lower end a steel threaded-type bushing is screwed into the steering-knuckle support. A threaded bolt which passes through both arms and the bushing completes the mounting.

Special seals protect the bearing from road dirt and water.

Two tie rods are used which connect directly to the Pitman arm—the offside tie rod is solid, but the nearside is adjustable to provide for toe-in adjustment.

Rubber bumpers for compression and rebound are mounted in the end of the frame front cross member. The lower bumper engages the lower spring seat bracket and the upper bumper engages the upper support arm at the point where the two arms are welded together.

To ensure the entire mechanism being as free as possible at all times, all nipples should be lubricated at least every 750–1,000 miles.

BRAKE MAINTENANCE—1939 CHEVROLET

To properly maintain the braking system, a thorough knowledge of the system is required. Particular care must be taken to see that all brake parts are thoroughly cleaned, and careful workmanship is very important in this connection. Absolute cleanliness is necessary to see that no foreign matter in the system will tend to clog the lines, ruin the rubber cups of the wheel and main cylinders, and thereby cause inefficient

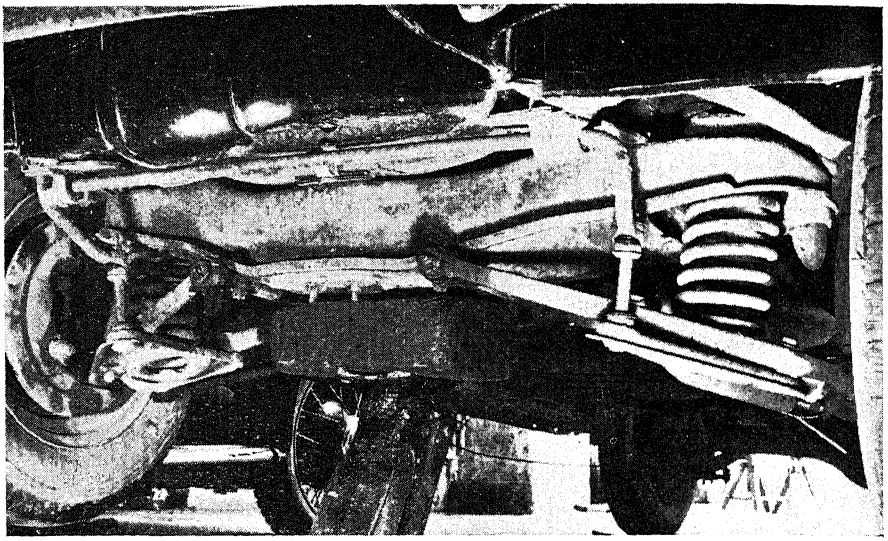


Fig. 18.—GENERAL VIEW OF FRONT-WHEEL SUSPENSION OF 1939 MASTER DE LUXE CHEVROLET

A simpler method to knee-action control will be noted.

operation or even failure of the system ; dirt or grease on a brake lining will cause a fade out on heavy application.

The hydraulic brake system must be bled whenever the pipe-line has been disconnected, or when a leak has allowed air to enter the system. The presence of a leak or spongy brake pedal usually indicates that air has been trapped in the system, and the entire system must be absolutely free from air at all times.

The longest pipe-line of the brake system should be bled first of all. Proper sequence for this operation is : left rear, left front, right rear, and, last of all, right front. During the bleeding operation the main cylinder must be kept at least half full of hydraulic brake fluid. The main cylinder automatically maintains the correct fluid level in the main cylinder during the bleeding process.

To Bleed the Hydraulic Brake System

Carefully clean all dirt from around the main-cylinder filler plug. Remove the plug, install adaptor and automatic filler. Open the automatic valve in the filler. Remove the bleeder-valve screw, attach bleeder drain pipe, keeping the end of the drain hose below the surface of the fluid in the jar. Unscrew the bleeder valve in the wheel cylinder half to three-quarter turn. Depress the foot pedal by hand, allowing it to return slowly. Continuing this pumping action forces the fluid through

the lines and out at the bleeder drain, carrying with it any air in the system. When bubbles cease to appear at the end of the bleeder drain hose and the stream is a solid fluid mass, tighten the bleeder valve and remove the drain hose. Replace and tighten the screw at the end of the bleeder valve.

After the bleeding operation has been completed, fill the main-cylinder reservoir approximately full and replace the filler plug.

Special attention must be called to the fact that fluid withdrawn in the bleeding operation should not be used again.

The correct fluid must always be used, which is Delco brake fluid.

In the event of improper fluid having entered the system it will be necessary to—

(1) Drain the entire system.

(2) Thoroughly and vigorously flush the system with clean methylated spirit.

(3) Replace all rubber parts of the system, and refill the system with the correct brake fluid.

Adjusting Brakes

These can be adjusted without the removal of the rear wheels. The adjusting hole for the front brake is located in the brake drum under the wheel flange, this will necessitate the removal of the front wheels to make the brake adjustments.

Floor-board clearance will very seldom need to be adjusted. The pedal stop, which is located in the brake master cylinder, is permanent. Before adjusting this stop, make quite sure that the pedal returns to the full released position freely, with no binding, and that the pedal return spring has not lost its tension.

To Adjust the Floor-board Clearance

Loosen the check nut on the eccentric bolt.

Turn the eccentric bolt in the proper direction to secure a $\frac{1}{2}$-in. floor-board clearance, and tighten the check nut.

Disconnect the emergency-brake pull rods from the brake cables. This can be done at the clevis just ahead of the emergency brake cable. It will be necessary for the emergency brake cable to be disconnected *before* the brake shoes are adjusted in the drums, to eliminate any possibility of a brake shoe dragging on the brake drum when adjusting the wheel cylinder, which avoids any possibility of false adjustment.

Jack up all the wheels so that they will rotate freely.

Insert a screwdriver in the adjusting hole in the brake flange plate and turn the adjusting nut four notches, to ensure the proper running clearance of the shoes and the drum.

Set the emergency brake lever in fully released position. The hand brake should be adjusted each time the hydraulic service brakes are adjusted.

Test car on road after each brake adjustment, to ensure satisfactory performance.

If upon dismantling the brakes it is found that the brake linings are worn, a satisfactory performance can be obtained by replacing only the forward shoes or brake linings when the back linings do not show excessive amount of wear. It is very often the case that the rear linings will outlast two sets of the forward linings. This is applicable to both front and rear brakes. Shoes or linings should always be changed in sets, namely, both forward shoes on the front wheels, or both forward and reverse on front wheels. The same applies to the rear wheels.

Correct brake linings are most important, otherwise faulty brake performance may ensue.

Do not use any abrasive on the brake linings ; drums must be heavily polished and thorough cleanliness must be observed.

Main-Cylinder Overhaul

In order to remove the brake main cylinder for overhaul it is necessary to carry out the following operations :

(1) Disconnect the main-cylinder pipe.
(2) Disconnect the wires from the stop-light switch.
(3) Remove the clevis pin from the piston push rod.
(4) Remove the main-cylinder retaining screws.

To Dismantle the Brake Main Cylinder

Remove the end plug and valve-seat washer and the valve-seat washer from the button on the end plug.

Remove the valve assembly and spring, the main-cylinder boot, the pedal-stop snap ring with a screwdriver, and also the pedal-stop assembly.

Dismantle the piston with the secondary cup and remove the primary cup.

After dismantling, all the parts should be thoroughly cleansed with *clean methylated spirit*.

Take special care to ensure that the compensating port in the main-cylinder housing and the bleeder holes are clean.

Before cleaning parts, thoroughly cleanse hands with soap and water.

Inspect the cylinder bore to ensure being smooth. Inspect the primary and secondary cups, valve, and valve seat for damage by grit or swelling. Replace parts when necessary.

Swelling of the rubber parts will be due to the use of improper brake fluid or the cleaning of the parts in petrol or paraffin.

Check piston fit in the cylinder bore. The clearance between the piston and the wall of the cylinder should be from ·001 to ·005 in.

Then check the clearance between the edge of the primary cup and the centre of the compensating port. In order to check this clearance, however, the main cylinder must be partially assembled, as follows :

(1) Install the pedal-stop assembly and lock in place with snap ring.

(2) Assemble the secondary cup on piston and install assembly in the housing. Place the primary cup in the housing, with the flat side of the cup against the piston.

(3) Push the piston and cup against the pedal stop and check the clearance between the edge of the primary cup and the centre of the compensating port. This clearance should be a minimum of ·035 in. This check is made easier by using a wire inserted through the filler hole of the housing and extending into the piston chamber. If the clearance is less than ·035 in., the primary cup must be replaced with a new one.

(4) After this clearance has been checked, the main cylinder must be again completely dismantled and reassembled according to the following directions :

To Reassemble the Brake Main Cylinder

After the hydraulic brake main cylinder has been overhauled for any purpose, great care must be exercised to reassemble the valves and seats correctly, as improper assembly of the seating rubber will result in distortion. There will be a consequent loss of brake-pedal travel, and the pedal must be depressed or pumped one or more times before actual car braking occurs.

In order to minimise the chances of distorting the check-valve seat, the following method of assembly is recommended.

(1) Insert a new check-valve seat washer in genuine hydraulic brake fluid, and assemble over the button on the end of the end plug. Assemble a new gasket over the end plug and screw the end plug, valve-seat washer, and gasket into the main cylinder housing. Tighten the nut securely.

(2) Inspect the valve-seat washer through the push-rod end of the housing, to make sure the washer is correctly seated.

(3) Dip the rubber cups and valves in genuine hydraulic brake fluid.

(4) Install the valve assembly from the push-rod end of the main assembly.

(5) Install the piston spring.

(6) Insert the primary cup in the housing, with the cupped side to the spring.

(7) Then assemble the secondary cup to the piston and assemble to the housing, so that the bleeder-hole end of the piston will be against the flat side of the primary cup.

(8) Install the pedal-stop assembly and lock in position with the snap ring.

(9) Install the rubber pedal-stop boot, ensure that the seal is tight on the housing, and that the vent hole in the boot is at the bottom. This seal must be tight to keep water and other foreign matter from entering the main cylinder through the pedal stop.

(10) After the main cylinder has been fitted to the chassis, it must be filled with genuine hydraulic brake fluid as previously stated, and all the pipe-lines at each wheel cylinder must be bled.

To Overhaul the Wheel Cylinder

In order to remove the hydraulic brake wheel cylinder, the car must be jacked up, the wheel and brake drums removed, the brake-system wheel cylinder lead pipe or hose disconnected at the wheel, and the brake-shoe return spring disconnected from the brake shoes. Two cap screws which hold the cylinder to the brake flange plate must be removed before the cylinder can be taken from the flange plate.

To Dismantle the Wheel Cylinder

Remove the cylinder adjusting covers, the pistons, rubber cups, and spring.

Wash all parts thoroughly in clean methylated spirit.

Inspect the cylinder bore to ensure that it is quite smooth. A scored or damaged cylinder must be replaced.

Check the rubber cups for damage or swelling due to incorrect brake fluid having been used. Replace the cups where or when necessary. Incorrect brake fluid will cause the cups to swell to a considerable extent.

Check the fit of the piston in the cylinder bore, using a narrow feeler gauge. The clearance should be ·003 in. and no greater than ·004 in.

To Assemble the Wheel Cylinder

Dip the pistons and rubber cups in the brake fluid.

Place the spring in the centre of the housing, the rubber cups at each end of the spring, the open face to the centre and the flat face of the cup flush with the piston.

Replace the adjusting covers with the adjusting screw in place.

Reassemble the wheel cylinder to the flange plate, connect the wheel-cylinder pipe or hose, and replace the brake-shoe return spring, brake drums, and the wheel.

After a wheel cylinder has been overhauled and replaced, it will be necessary for all hydraulic-brake lines to be bled.

In conclusion, particular care must be taken to ensure that the methylated spirit which has been used for cleaning out a system containing some mineral oil should never be used again.

SPECIAL POINTS TO BE WATCHED WHEN REPAIRING GUY COMMERCIAL VEHICLES

THE TRANSMISSION, AXLES, AND STEERING GEAR

By R. A. BISHOP

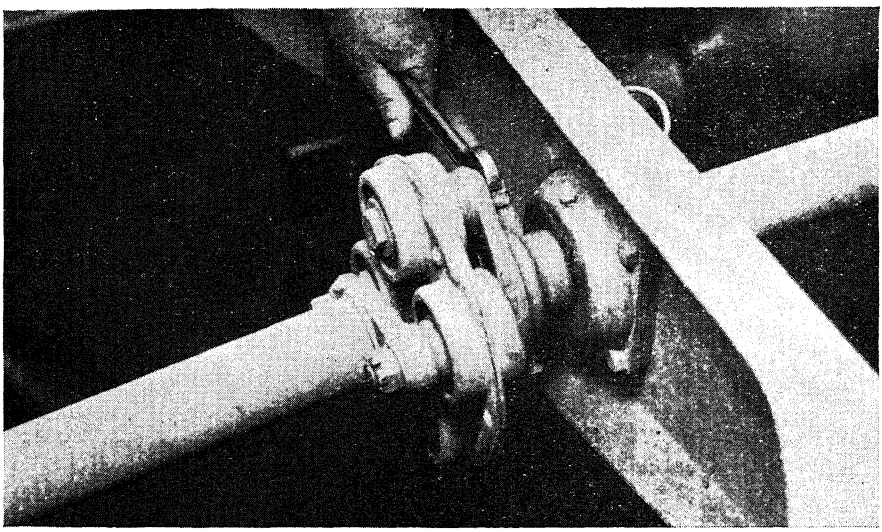


Fig. 1.—UNCOUPLING TRANSMISSION
Note washer between nut and rubber trunnions.

Transmission

THE transmission includes Layrub all-rubber universal joints, which require no lubrication whatever, as there are no moving parts.

For dismantling purposes it is necessary to remove the connecting bolts and compress the rubber trunnion block to the depth of the spigot bearing, which is approximately $\frac{1}{8}$-in., when the shaft can readily be removed.

Care should be taken on reassembly to see that the washers are fitted

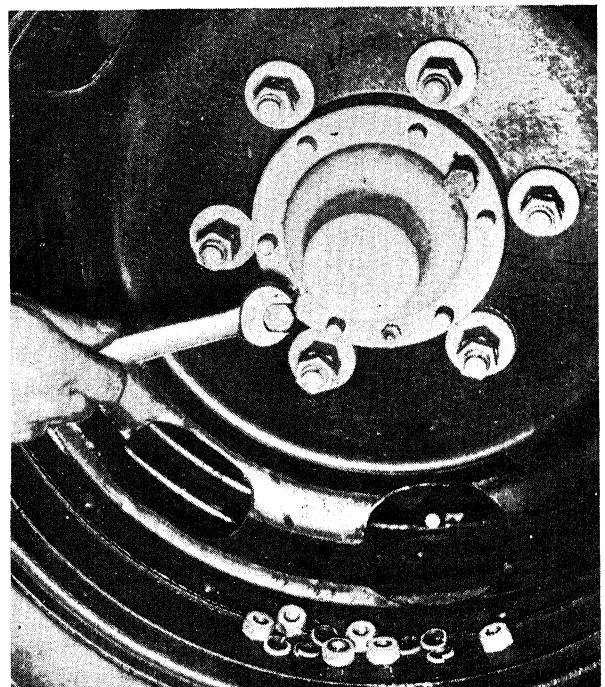


Fig. 2.—REMOVING DRIVING FLANGE BY TWO SET-SCREWS

under the shank or head of the bolt, and on no account should the hexagon-head bolts come into contact with the rubber trunnion block.

The slotted nuts should be tightened up to their full limit. The sleeve bolts are made from 3 per cent. nickel heat-treated steel, and care should be exercised to see they are tightened fully.

The intermediate bearing in the propeller-shaft line is of the radial type, and this should be periodically lubricated by the nipple provided.

Where the universal joints are of the all-metal type, lubrication is necessary at the sliding end of the shaft, by means of the nipple on the yoke shaft. These are lubricated for the first 5,000 miles, but the splines require a good grade of semi-fluid lubricant every 2,500 miles.

To lubricate the joint proper, remove the filler plug in the spider and inject a good grade of semi-fluid lubricant. The pressure-gun and fitting should be cleaned to avoid possibility of injurious foreign substances entering the joint.

When the joints are subject to heavy duty, it is well to remove the bearings twice a year, or every 30,000 to 40,000 miles, for inspection, cleaning, and repacking. It is a simple matter to disassemble the joints. Take out the eight bearing-cap screws and remove the bearings and spider. It is not necessary to take out the propeller-shaft assembly from the chassis, as each joint may be dismantled without removing the propeller shaft from the front slip joint.

After dismantling the rear joint, clean each bearing thoroughly and repack with a high-grade semi-fluid lubricant. Then reassemble the rear joint. Now dismantle, clean, and lubricate the front joint in the same manner without removing the slip yoke from the propeller-shaft splined stub.

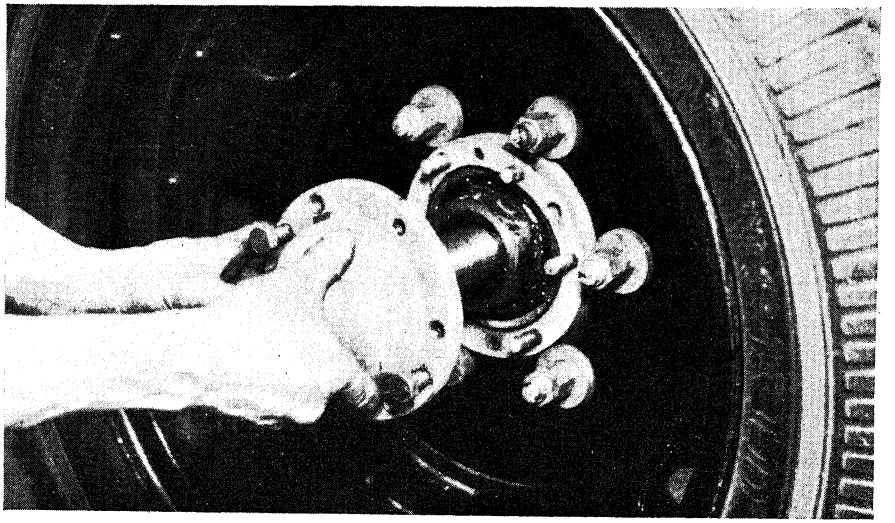


Fig. 3.—WITHDRAWING DRIVING FLANGE COMPLETE WITH HALF-SHAFT

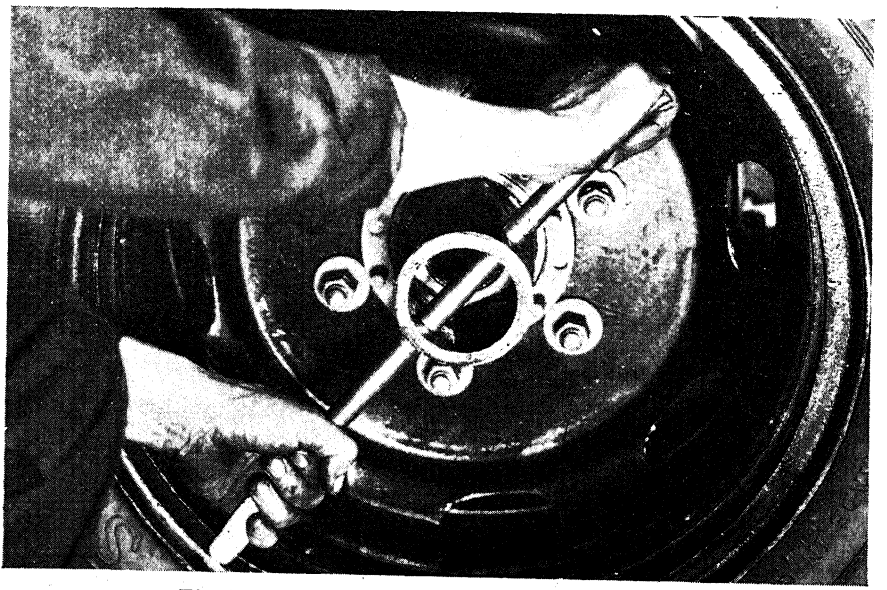


Fig. 4.—TIGHTENING RETAINING NUTS ON REAR HUB

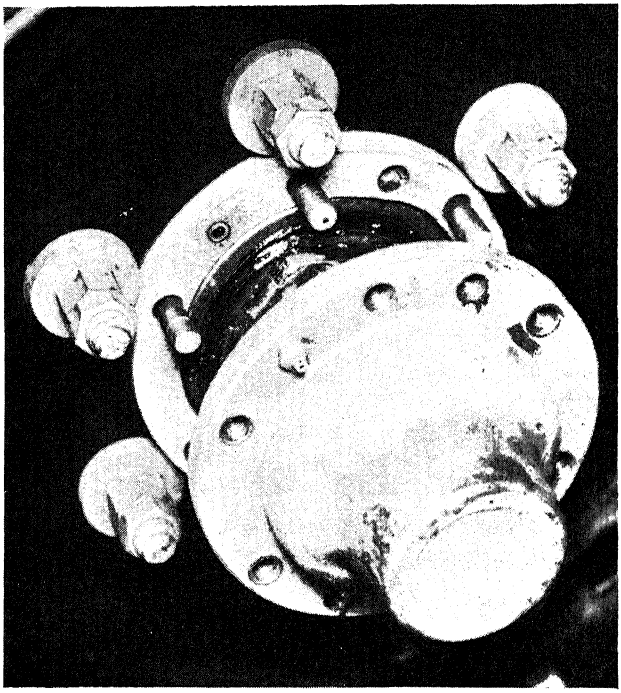


Fig. 5.—REPLACING DRIVING FLANGE

Showing position of cork washer when replacing driving nge. The grease hole should be in line with the grease nipple.

Reassembling the Transmission

The inexpensive cork seals should be replaced by new ones, when reassembling. It may be necessary, also, to replace the bearing-cap screw lockplates.

When the joints have been reassembled, make sure that the lockplates are turned up against the heads of the cap screws, so as to keep these in place.

To Remove Rear Hubs

First remove the road wheels, then driving-flange bolts, and withdraw flange complete with axle shaft. The driving flange may be eased off the spigot by inserting two setscrews in the tapped holes provided. Then remove the two rear-hub retaining nuts and lock-washer, when the hub can be withdrawn complete. When replacing the rear hub it should be noted that the two retaining nuts should be tightened up securely, as the bearings are of the ball-and-roller type and do not require endwise adjustment. Another important point is that the cork washer between the hub and the driving flange should be replaced so that the hole in this coincides with the hole for the grease nipple in the driving flange.

To remove Rear Drum

First remove the road wheels, then the six countersunk setscrews which secure the drum to the hub. The drum can then be removed, leaving the hub in position. When replacing the drum take particular care that it is mounted in exactly the same position as before removed, as if it is out of

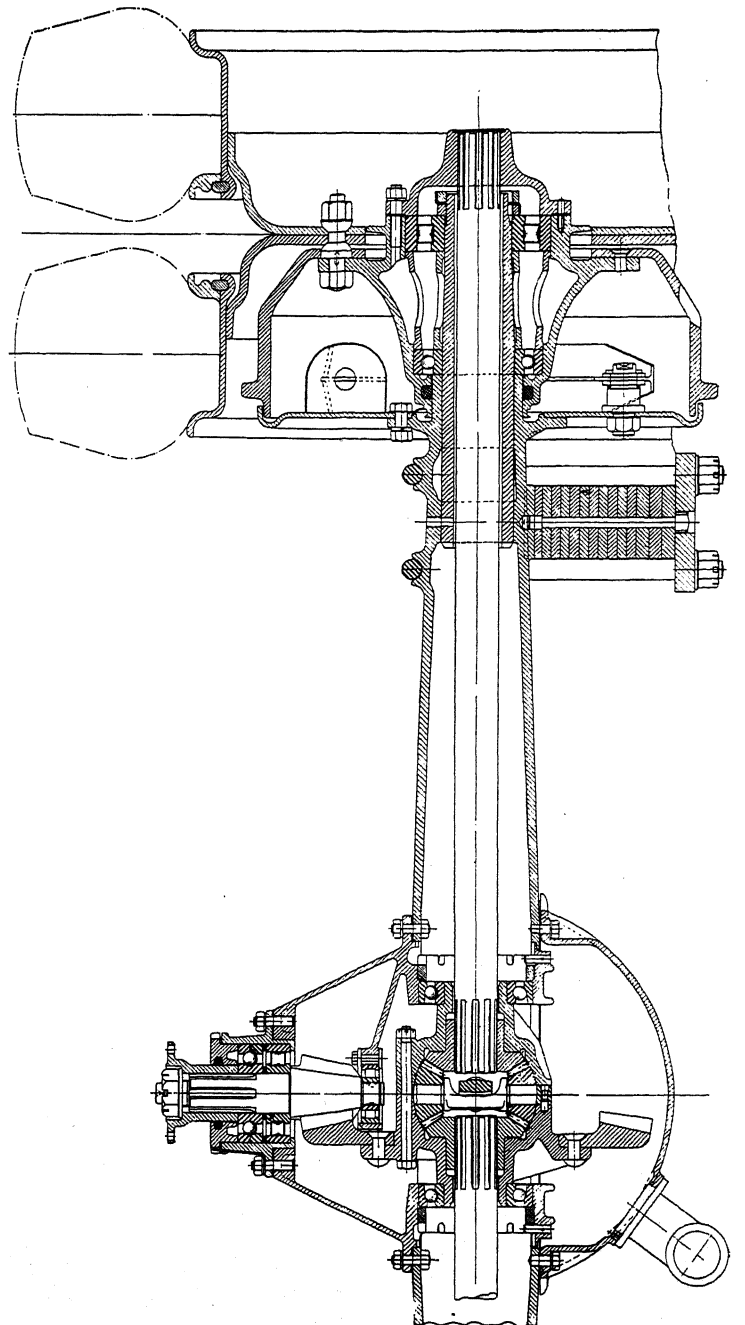


Fig. 6.—ARRANGEMENT OF REAR AXLE ("OTTER")

truth when refitted the operation of the rear brakes will be seriously affected.

Dismantling Rear Axle

With the axle shafts withdrawn and the propeller shaft disconnected, release the nuts holding the front cover of the rear axle in place, when the cover, complete with differential gear, may be lifted out.

After removal of the bevel gear and differential unit from the casing, it may be dismantled by removing the oil-retaining ring and locating bar which prevents the nut at the forward end of the casing from rotating. When that nut is unscrewed, the bevel pinion with its shaft and ball races will pull out. To dismantle the differential gear remove the two bearing caps to free the crown wheel and differential case. When the bolts holding the differential casing to the crown wheel are removed, the former will come away in halves, to expose the differential gear. Adjustment is by means of locking nuts at each side of the differential casing and at the end.

Brakes

These are of the Lockheed or Bendix type. These types are considered in Vol. I, and it is not necessary to describe them here or to refer to maintenance.

Front Axle

The front axle is an " I "-section steel forging, oval at ends to take braking torque. The hubs are mounted on taper roller bearings. Both swivel axles are fitted with hardened-steel bearings in upper and lower jaw, each lubricated by means of an accessible grease-nipple. The pivot pins are of hardened steel, each cut with a slot to take a taper pin, ensuring a firm fit in the axle boss. Each pivot pin is fitted with a taper roller thrust bearing between the bottom of the axle boss and the lower jaw of the swivel axle.

Front Hubs

To remove hubs jack up axle and unpin and remove the castellated nut, lock-washer, spacing washer (drilled with eight holes), collar, and shim. The hub and brake drum can then be drawn off, complete with the outer bearing. If the oil retainer and the dust cover behind the inner race are removed, care should be taken when refitting that the small hole at the bottom of these mates up with dowel in the stub axle. The correct alignment is when the measurement between the rims is $\frac{1}{8}$ in. less at the front than at the rear of the wheels, measuring at the line of the hubs. To adjust for track, take out one of the ball pins from the track-rod arm, slacken off clamping nut. The track rod can then be unscrewed or screwed up as required, but do not forget to tighten the clamp screws after the steering is properly set.

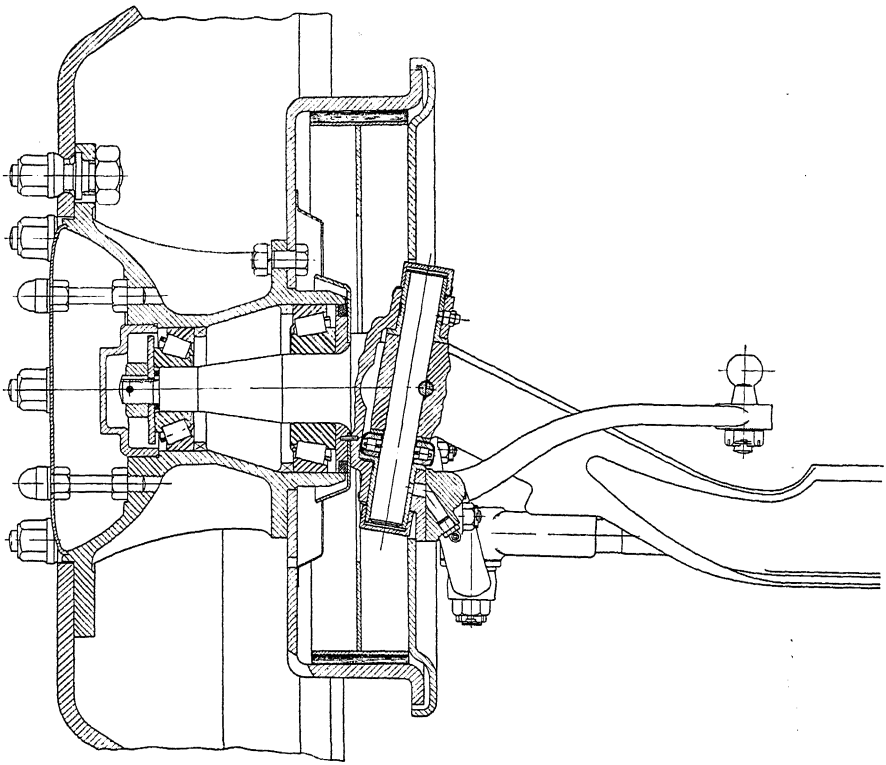


Fig. 7.—SECTION OF FRONT HUB AND SWIVEL AXLE

To dismantle Stub-axle Assembly

Remove front-brake assembly and backing plate. Remove taper pin in axle boss. Unscrew brass hexagonal nuts top and bottom, together with locking washers. Pivot pin can then be removed top or bottom. It will be noted that the slot which locates the king-pin is not centrally placed when refitting, therefore care must be taken to see that this slot corresponds with a similar slot in the axle beam. It should be noted that the bottom bush has a flat on the edge of the flange. Before refixing the top and bottom brass hexagonal nuts see that the locking washers are fitted.

Play in Stub Axle

As the pivot pins and bushes are of hardened steel it is unlikely that wear will develop in these. Should end play eventually occur in the stub-axle assembly, this can be taken up by inserting another packing washer between the thrust bearing and the lower portion of the axle boss.

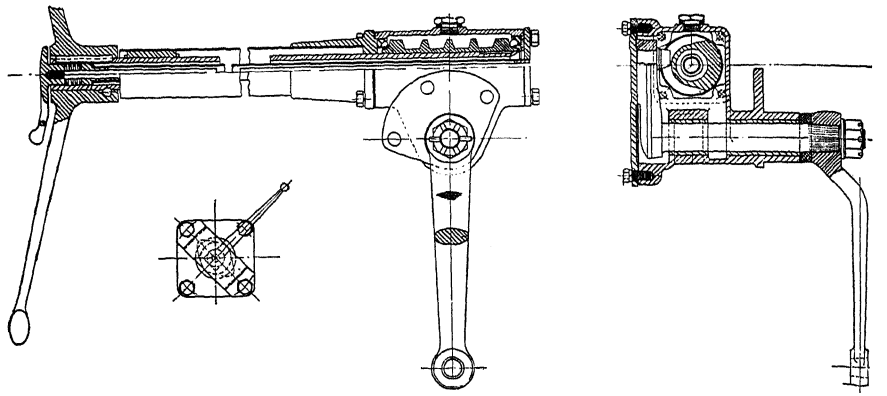


Fig. 8.—SECTION OF STEERING GEAR

The correct adjustment is such that the bearing is very slightly " nipped " between the stub-axle bosses when the vehicle is jacked up.

When replacing the taper thrust bearing on the lower portion of the stub axle, take care that this is fitted correctly, i.e. with the portion marked " Top " nearest to the axle boss.

Steering Gear

The steering gear used is of the cam-and-roller type. As will be seen from the illustration above, this gear is a self-contained unit of extreme simplicity. The whole of the mechanism is contained in an oil-tight casing, and replenishment of the oil at intervals of about six months is the only attention that is likely to be necessary on the part of the owner.

Lubrication

On no account must grease be used. Use heavy gear oil or " Kamoil," a lubricant specially manufactured for this steering gear. The box may be kept as full of lubricant as possible. The internal mechanism is automatically lubricated, but a spot of oil should be injected with an oilcan from time to time into the recess surrounding the stationary tube of the central control at the top of the steering wheel, and also to the bearing at the top of the outer column.

Adjustment

The cam and main shaft are mounted on ball bearings which take the thrust from the rocker shaft, and shims are fitted under each end cover so that the cam is mounted centrally in the box. It should never be necessary to alter the adjustment, which is carefully set before the vehicle leaves the works, but if the gear is dismantled for cleaning or inspection a careful note of the number of shims at each end should be made. On

reassembly the shaft should spin with the fingers, but there must be no play whatever.

Rocker Shaft

The motion of the steering wheel is transmitted to the road wheels through the cam and roller fitted into the lever inside the steering box, and in time a small amount of wear may possibly become apparent. This will be shown by loose motion between the steering wheel and the drop arm. The whole of this can be removed and the gear restored to its original perfection by removing one or more of the shims from underneath the cover plate on the side of the steering box. If too many shims are removed the gear wheel will become stiff, and this must not be permitted.

All adjustments to the steering gear should be carried out with the drag link disconnected.

Removal of Drop Arm

The drop arm is attached to the rocker shaft by means of a splined taper, and secured by a slotted nut. It may be difficult to remove the drop arm from the shaft unless a drawer is used on the lugs provided for this purpose. If it is ever necessary to remove the drop arm with a hammer, the side cover plate must first be moved, and the shaft should be driven through the drop arm so that the reaction from the blow is taken on the main casing instead of on the hardened-steel cam and roller.

When replacing the drop arm take care to refit it to the correct spline to give an equal lock. The most simple method of finding the correct position is to attach the drop arm to the drag link by the ball pin, place the road wheels in a " straight ahead " position, and turn the steering wheel as far as it will go on the left lock, then bring it back three-sevenths of its full motion and mount the drop arm on the spindle in this position. Care must be taken to ensure that the slotted nut is tightened right home, and the nut securely split-pinned. The front axle should then be jacked up to see that there is full lock on both sides, and that the stub axles are properly up against the stops on the front-axle bosses.

The only thing that can cause the steering to become stiff in use (apart from the front axle and its connections) is lack of lubricant between the revolving shaft and the steering gear and the stationary tube of the central control, or lack of lubricant in the box itself.

When properly adjusted the steering should be finger light, free from backlash, no road shock should be felt on the wheel, and the vehicle should straighten up well after cornering.

Tyre Pressures

The correct tyre pressures for the " Vixen " and " Otter " 3- and 4-tonners are as follows :

Tyre Size	*Pressure (lb. per square inch)*
32 × 6·00 Low pressure	Front—45. Rear twin—50.
32 × 6·00 High pressure, truck type . .	Front—80. Rear twin—80.
32 × 6·00 Heavy-duty	Front—80. Rear, single, or twin—90.

Body

Body squeaks are generally rather difficult to locate, but should a squeak develop it should be traced to its source and rectified, as it means that strain and consequent wear are being imposed at this point.

Occasionally, the tightness of the body holding-down bolts should be checked with a spanner. This will prevent any possibility of the body bolts shearing or a dull chattering occurring when passing over a rough road, due to the body moving on the chassis.

SERVICING COMMER VEHICLES

REAR AND FRONT AXLE, PROPELLER SHAFT, STEERING AND BRAKES

By B. M. SMITH

IN dealing with the repair of Commer vehicles it is convenient to separate the entire range into three general types, i.e. 8 cwt.; 15 cwt. and 20/25 cwt. (type N.1); and N 2/3 and 5 tons.

8-CWT. VAN

Rear Axle and Propeller Shaft

The rear-axle unit is a semi-floating type with spiral bevel drive of conventional pattern, and should present no special difficulty.

The following remarks apply to all vehicles up to chassis number 7100499, but a different procedure is necessary for the axle now in use fitted to chassis 7100500 and onwards.

The complete unit can readily be detached from the rear axle casing after removal of the axle shafts, and all roller bearings are adjustable.

The hub is integral with the axle shaft, and is removable after the brake drum has been detached to allow removal of the three nuts securing the hub-bearing retainer plate.

When replacing, the retainer plate must be refitted so that the clearance for the two nuts in the backing plate is opposite these two nuts.

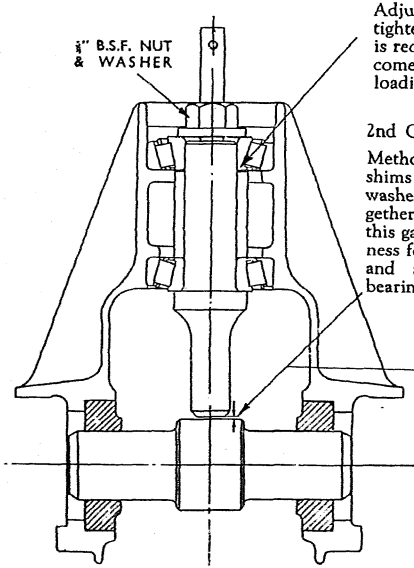
The complete pinion assembly can be withdrawn by undoing the nuts holding the casing—taking care to replace the same shims, unless the axle mesh has been adjusted.

The assembly can be refitted only with the two drain holes at the bottom.

Dismantling is effected by removing the drive flange, after which the pinion shaft and rear bearing can be pressed out, preferably leaving the oil seal and front bearing in place.

Adjusting shims are fitted between the rear race and distance-piece to allow wear in the bearings to be taken up.

To dismantle the differential remove bearing caps, first marking the adjuster to ensure reassembly with the original adjustment, and lift the unit out complete, taking care also to mark the outer bearing rings so that they are correctly replaced.



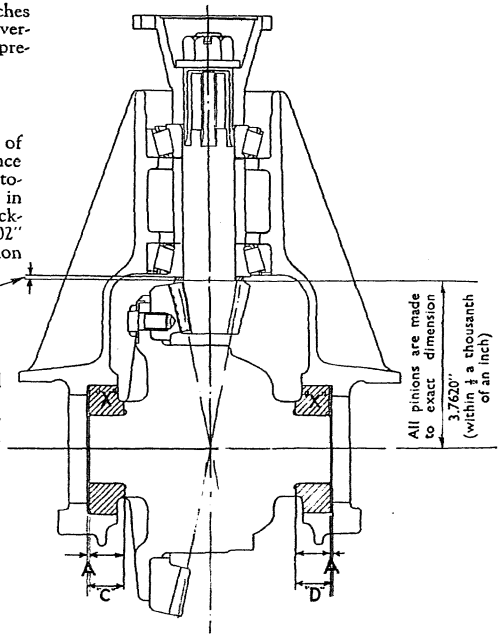
1st OPERATION

Adjust pinion bearings so that with nut tightened a measured torque of 3 lbs. inches is required to be applied to the shaft to overcome the resistance to rotation due to preloading.

2nd OPERATION

Method of obtaining correct thickness of shims for pinion. Actual .060" thick distance washer P.56167 used in the assembly, together with feelers or shims to be tried in this gap, which will then give correct thickness for positioning of pinion. Deduct .002" and add this to shims adjusting pinion bearings.

NOTE.—These distances are equal if correct shims have been used. Difference of .002" arises over relative tightness of pinion bearings on dummy and pinion shafts.



3rd OPERATION

For obtaining correct shim thickness for positioning crown wheel:—

(a) Slip dummy bearing discs 'X' on ends of differential carrier, insert feelers at point 'A' with correct back lash between gears.

(b) Obtain distances 'C' & 'D' by adding together thickness of feelers used plus .002"

(c) Measure exact overall height of actual bearings to be used and subtract from dimensions 'C' & 'D' this will give actual thickness of shims required. Add .001" to each side.

Removal of the bolts passing through crown wheel and differential box will allow the latter to be split for access to the differential pinions. The two differential halves are marked to ensure correct reassembly.

Differential Adjustment

Longitudinal adjustment of the bevel pinion is by means of shims between the pinion nose-piece and differential casing.

These shims can be fitted only one way, with the elongated hole on the bottom right-hand or 5-o'clock stud.

So far as the present axle unit is concerned, although all bearings are still adjustable by means of shims, no screwed adjusters are incorporated. Dummy shafts are used to determine the shims required. Should it be necessary to alter the adjustment the following sequence must be adopted :

Remove bearings, shims, and distance-piece from pinion shaft and build up dummy shaft with the pinion housing, after removing the oil seal, finally fitting coupling nut and washer and tightening fully.

Check bearings for adjustment, adding or removing shims as required from between distance-piece and bearing.

When correctly adjusted, the bearings should be pre-loaded. This amount is measured by testing the torque required to turn the shaft, which should be 3 lb. in.—equal to a load of ½ lb. on a 6-in. lever.

The lever arm can be inserted in the tommy-bar hole in the dummy shaft and load applied by a spring balance.

Having established the correct pre-load, fit the centre jig into the casing, using the two dummy bearings.

The gap between the end of the dummy shaft and the centre jig should be measured with feeler gauges *and* the original spacer washer.

The measurement taken by the feeler gauges is the thickness of shims to be built on the pinion shaft when reassembling.

In practice, in fitting the bearing on the shaft it alters its length by ·002 in.

This should be *subtracted* from the thickness of shims required to fill the gap, and *added* to the shims at the end of the distance-piece between the bearings.

Therefore, to build up the pinion shaft, first fit the thick washer, chamfer downwards, then the correct number of shims as determined. Next press on the inner member of the rear bearing, following with the shims with ·002 in. added—and then the distance-piece.

Now refit oil seal to casing, coating the outer cage with quick-drying compound, finally rebuilding the pinion into the casing.

This completes the pinion assembly.

Having reassembled the differential box remove the two bearings, and in their place fit the dummy bearings without shims.

Assemble in the housing, still using the dummy bearings, and fit the caps.

With a suitable length of tube, drive the dummy bearings inwards until the correct backlash between the gears can be obtained.

Measure with feeler gauges the gap *A* shown on Fig. 1.

Obtain distance *C* and *D* by adding ·8 in. (the thickness of the dummies), to the size of gap *A*.

By measuring the height of the actual bearings and deducting from *C* and *D*, the thickness of shims required can be obtained.

It is recommended that an additional ·001 in. be added to each side.

There are two methods of measuring the height of the bearings, in each case using the dummy as a comparison.

The first is by use of a surface-plate and a dial gauge—setting this to give a zero reading by use of the dummy bearing. The reading is then taken on the actual bearing, the amount shown on the gauge being the difference.

Alternatively, a straight-edge can be laid across the bearing and the dummy, the difference being measured by feelers.

Now remove differential box from casing, withdraw dummy bearings, and fit the necessary shims in accordance with the dimension obtained in the manner just detailed.

Press on the bearings, replace the complete assembly, and tighten up the bearing caps.

Oil Seals

A spring-loaded leather oil-seal assembly is fitted to the pinion nose-piece, and if at any time it is renewed the outer edge of the seal should be coated with jointing compound before assembly, to prevent leakage between the seal and case. The sharp edge of the leather must face the rear axle. A similar seal is fitted in the rear hub to prevent oil passing up the shaft from the differential.

In addition, a felt is fitted in a housing on the catcher spot welded to the bearing retainer plate.

Should leaks occur at the rear hub, make sure that this is not due to over-lubrication of the hub bearings.

A catcher is spun on the rear of the hub, and it is important that the drain holes drilled in the hub, brake drum, and wheel be kept clean, to prevent surplus lubricant finding its way on to the brake shoes.

Propeller Shaft

This is of the Hardy Spicer needle-roller type, and as all bearings are packed with grease when new, it is necessary only to grease the splined portion.

The shaft must be fitted with the sliding part to the front of the car.

Further, the front and rear joint lugs must be in line and not at 90° to each other.

Brakes

These are of Bendix duo-servo type, and full details of maintenance and adjustment are given in a special section in Vol. I.

It is recommended that there be a slight lead on the front brakes, say 60 per cent. on the front to 40 per cent. on the rear.

The necessity for using only genuine replacement shoes is again stressed, as it is not possible to obtain satisfactory braking if new liners only are fitted. Periodic lubrication of the cables is essential, using Bendix graphite grease, and all moving parts should also be inspected and greased to ensure freedom of movement.

Important

Under no circumstances must an endeavour be made to adjust the brakes by altering the lengths of the cables.

Front Axle

The swivel pins are carried in the axle beam and secured by taper cotters.

To dismantle the stubs, the pins must be driven out after removal of the cotters, and to facilitate this they are drilled and tapped in the top to take a special extractor.

If this is not available, the pin may be driven downwards with a suitable drift.

Should it be necessary to fit new bushes, these should be reamered to suit the pin after they are pressed into position.

The track should be maintained at all times with $\frac{1}{8}$-in. toe-in.

The track-rod ball joints are of the self-adjusting type. Should any play exist this may be due to the self-adjusting mechanism becoming jammed or rusted up.

Grease should therefore be forced in, and the joint well worked to release it.

Steering

The steering gear is a Burman-Douglas unit, of the steel worm and bronze nut type, the nut in turn operating the rocker shaft. Full details as to maintenance and adjustment are given in a separate section in Vol. I.

To remove the steering unit, this should be withdrawn downwards, with the car over a pit, leaving the detached steering wheel and controls in the van.

It is recommended that a long piece of string be tied to the wires in the inner column before removal.

This will be drawn up the column and should then be detached and left in place to facilitate reassembly.

It is also advisable to mark the steering wheel, to ensure that it is replaced in correct relationship with the inner column.

15 CWT. AND 20/25 CWT.

A Hardy Spicer needle-roller type propeller shaft with 1300-size universal joints is fitted, and no running attention beyond lubrication of the slip spline shaft is required. No provision is made for greasing the needle bearings, but it is recommended that these be taken down and repacked with grease periodically, say when dock overhaul is taking place, or every 2,000–3,000 miles.

To remove Propeller Shaft

Remove all bolts from the flanges holding shaft to gearbox and rear axle, telescope shaft on splines, and it will then have shortened sufficiently to permit being lifted away.

When entering splines to replace slip joint on shaft, assemble so that sleeve-yoke lugs lie in the same plane as stub ball-yoke lugs. Arrows are stamped on sleeve and shaft for this purpose, and need only be placed in line. Special steel bolts with lock-washers under both head and nut are fitted to the coupling flanges, and no others should be used.

Replacement of Needle-bearing Assemblies

This can be done if necessary without removing shaft from vehicle, but the work can be carried out much more easily on a bench ; in either case the procedure is the same. Take out the snap-rings holding an opposed pair of needle-bearing assemblies by means of pointed pliers, and with the yoke from which the rings have been removed supported, tap one of the bearings—using a suitable drift—until the one on the opposite journal lug is released and can be lifted away. Now, with a piece of wood or a soft-metal drift, tap on the exposed end of the journal and the other assembly will be forced out. This procedure is followed to extract all the bearings.

In reassembly pack bearings with high-speed grease only ; many failures can be traced to the use of unsuitable lubricant.

It is generally found advisable to renew the needle-roller assemblies in sets and at the same time fit new journals. Care should be exercised to see that the oil gaskets are undamaged by removal of the bearings ; if any doubt as to their efficiency exists, a new journal assembly should be fitted. The makers do not supply these gaskets separately to the journals, as a special process is necessary in assembling the two details.

REAR AXLE (15 CWT. AND 20/25 CWT.)

The rear axle is of the semi-floating type, spiral bevel pinion and crown wheel being fitted. The forward end is a casting in which the whole of the gear set is carried, and this can be removed after withdrawal of the driving shafts.

Taper roller bearings are fitted, and provision for adjustment is provided in all cases.

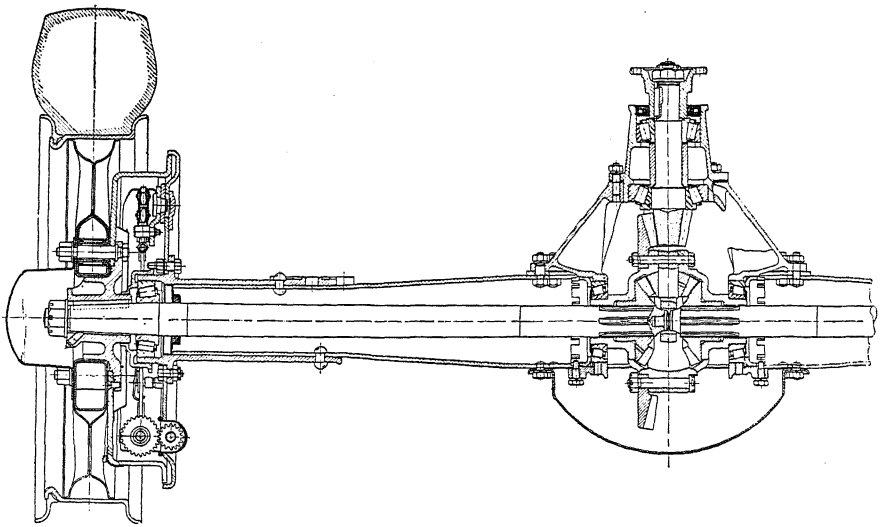


Fig. 2.—ARRANGEMENT OF REAR AXLE, TYPE 15 CWT.

Removal of Axle

This can be done either by taking off the nuts from the spring-holding U-bolts or by withdrawal of the spring shackle pins. The amount or nature of the work to be carried out will decide which method is adopted ; the procedure is quite straightforward and will present no difficulty whatever. Brake cables should, however, be detached at cross-shaft.

If removal of the banjo is undertaken, one point to watch is that the makers carried out a modification to spring location and, as only the latest type banjo is now supplied, some doubt may arise in fitting.

Briefly, the first type of spring location had the dowel bolt machined in two diameters, the larger diameter locating in the spring bracket and the smaller projecting through a hole drilled in the casing itself. Subsequently, to prevent drilling the casing, the smaller diameter was dispensed with, the dowel bolt being shortened by this amount.

Replacements of this later type of case will be received, and in fitting to a spring in which the old type of dowel bolt is employed it will be necessary to cut away the small diameter of the bolt. It is hardly necessary here to emphasise the importance of following up the spring holding-down bolts if these have been disturbed.

Adjustment of Wheel Bearings and Withdrawal of Axle Shafts

Take off road wheels and brake drums ; it will be noted after removal of the wheel that the drum is fastened by countersunk setscrews to the hub ; extract these and the latter can be lifted away. If it is desired only

to *adjust wheel bearings*, this can now be carried out without further dismantling by turning back the adjuster locating screw and screwing in adjuster until tight, slack back about eight notches, and lock. Adjustment of one bearing will be sufficient if there is only slight play, but if more than one complete turn of the adjuster is required, it should be divided equally between both sides.

There is no necessity to separate the hub and axle shaft, as they can both be removed as one unit by unscrewing the bearing adjuster as far as possible and withdrawing shaft with its bearing to the limit permitted, this operation then being repeated until the assembly is clear of axle.

A felt oil-retaining assembly will be found pressed into the axle casing at the hub end of tube and in case of excessive oil leakage may need renewing. It is advised that only high-speed grease be used for the hub bearings, and this only in reasonable quantity, for obvious reasons.

Should it be necessary to part hub and shaft use a withdraw claw, especially if this is being done with driving shaft still in axle. In case a new hub is being fitted to an old shaft, or vice versa, make sure that tapers are a perfect fit by grinding one in the other with very fine grinding-in paste. Do not use a file or emery-paper.

On later-type machines, it will be found that wheel studs are dowelled to the hub and it is advisable to carry out this modification on the earlier machines when opportunity occurs. Suitable studs and dowels can be obtained from the makers or, of course, the shoulder on the existing studs and the flange of the hub can be drilled, location being by means of $\frac{3}{16}$-in. steel wire.

Adjustment of Differential Bearings

This can be carried out with axle still assembled, access to the adjusters being obtained by removal of rear cover.

The bearing-cap nuts must be slackened a little and the adjuster locking screws taken out of bearing caps. Adjust until there is no perceptible slackness left by screwing in both adjusters an equal amount.

The correct backlash between the pinion and crown wheel will permit approximately $\frac{1}{32}$-in. movement on the propeller shaft driver coupling when the crown wheel is wedged.

Check that locking screws are replaced correctly and cap nuts tightened up.

Pinion-bearing Adjustment

This is a further operation which can be carried out without completely dismantling the axle.

First remove bolts holding propeller shaft and pull clear of axle. The pinion sleeve, complete with the bevel pinion, roller races, and propeller-shaft coupling, must now be taken from the differential housing. Shims will be found between these two members for adjusting the gears.

The shims must be returned exactly as originally fitted unless renewal of crown wheel and pinion is being undertaken. Instructions relating to this operation are given in the following section.

Remove driver coupling and key from pinion and the latter may then be tapped out of housing, shims in 25 or 40 S.W.G. for bearing adjustment being immediately between the front bearing and distance-piece. Shims may be removed until there is no perceptible end float ; do not, however, pre-load the bearings.

Crown Wheel and Bevel Pinion Replacement

As previously indicated, the whole of the gear set is carried in the differential casing which, after withdrawal of axle shafts, can be removed subsequent to the ring of nuts holding it to axle being taken off.

Apart from dismantling of bevel pinion, procedure for which is given above, no problem will be found in stripping the unit.

In order to reassemble, put differential, on which the new crown wheel has been fitted, into casing and by means of bearing adjusters centralise unit as nearly as possible. Tighten up bearing-cap nuts sufficiently to hold the assembly firmly, but do not split-pin.

Now assemble pinion in housing, adjusting the bearings as indicated above, and without any shims between the pinion housing and differential casing insert the former until the " lapping-in " marks on the pinion coincide with those on the crown wheel. Ascertain number of shims required between pinion housing and casing by offering them edgeways until exact thickness has been found. Shims are obtainable in thicknesses of ·005 in., ·016 in., and ·032 in. It is advisable to add one ·005 in. extra to compensate for nipping, and after putting these on studs the pinion assembly can be finally tightened on the differential casing.

Finally, the crown wheel must be adjusted sideways as indicated under " Adjustment of Differential Bearings," and the meshing tested by means of marking blue.

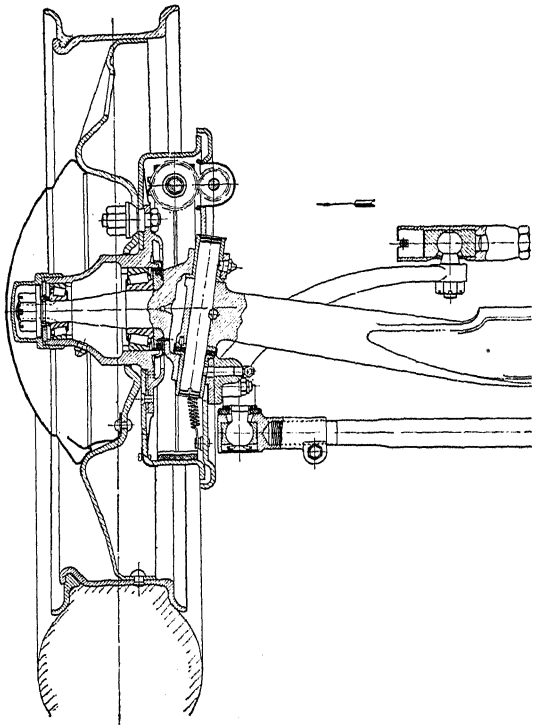
FRONT AXLE (15 CWT. AND 20/25 CWT.)

Front-axle beam is of I-section between spring pads changing to oval section at the ends. A Thompson track rod is employed, and the wheel bearings are of the taper-roller type.

Removal of Front Axle

On the N.1 forward-control model the axle is held to the springs by eight bolts, but the remaining types utilise U-clips. The nuts on bolts or clips must be removed and the side rod disconnected from the steering ball in either steering arm or drop arm. (If the split-pin is taken out of the side rod, the end plug can be screwed back and the ball will be released.)

Detach brake cables from cross-shaft and the unit can be rolled forward.



g. 3.—ARRANGEMENT OF FRONT AXLE (TYPE N1)

Dismantling

Dismantling is extremely simple and commences, of course, with removal of wheel and nave plate. On all the 15 cwt. and also the early N1's, the nave plate is held by the wheel nuts or, alternatively, setscrews fitting in the wheel nuts, but the later type N1 nave plate is fitted on springs riveted to the wheel: this type is easily sprung off by the insertion of a screwdriver.

Screw off hub cap (right-hand thread both near and offside) and remove stub axle end nut, bearing tab washer, distance-piece, and safety washer. Hub and brake drum can now be drawn off, and all hub parts will be available for inspection.

Before swivel pins can be removed it is necessary to take off brake backing plate—which is held to stub by six bolts—in order to give required clearance. It will be noted that the two bottom bolts also hold the steering arm, and releasing the arm here obviates the necessity of disconnecting the track rod.

It is now necessary to point out the effect of modifications affecting both swivel-pin bushes and the method of pin location.

The first type of pin employed was of hollow tube located by a taper pin ; the later of solid bar fixed by cotter and nut.

Dealing now with the bushes, it will be found that the first were closed by a cap nut screwed on and held in place by a lock-washer. The later have a sealing disc in the end of the bush in which a groove is cut to receive it. Location of the bottom bush throughout is by a flat cut on the side of the bush butting against the steering arm, and the cap nut held the top bush when the bush was fitted ; now, however, the top bush is positioned by a special-type greaser.

After removal of backing plate and steering arm it will be seen that there are alternative methods of extracting swivel pins. In the first case, turn down lips of cap-nut locking tabs, unscrew cap nuts, and drive out

taper or cotter pin. (It is pointed out that as the above modifications did not take place simultaneously such an alternative will apply.) The swivel pins can now be tapped out.

In the second case simply remove cotter pin and with a suitable drift on the sealing disc in the bush drive this and the swivel pin through until the disc at the opposite end is released. Now change the drift to the exposed end of the pin and drive same completely out, sending the remaining sealing disc before it.

Reassembling Front Axle

In reassembly the swivel pin *must* be a tight press fit in the axle, and if any doubt exists fit one of the oversizes which are obtainable : + ·005 in., + ·010 in., and + ·015 in. An oversize pin will, of course, necessitate an oversize bush, and these being of steel the makers have made provision to supply in the same oversizes.

The steel thrust washer on the swivel pin is dowelled to the axle bed, and this point should be watched, as also that there is clearance between the swivel pin and the interior diameter of the bronze thrust washer.

The hub oil guard and distance-piece are dowelled and an oil-return felt is fitted between them. When replacing, be sure that the felt is not trapped between the hub and oil guard.

Adjustment of wheel bearings is carried out by means of the nuts on the stub-axle ends, and there should be just appreciable shake in the bearings.

Wheel Alignment

Correct "toe-in" is $\frac{1}{8}$ in. measured at hub centre-line of wheel, and the same point on the centre of tyre tread should be used at both front and rear.

One of the track-rod sockets has a left-hand thread and the other a right-hand thread. It is necessary only to loosen the clamping bolts in the sockets and turn the intermediate either in or out as required.

Steering Gear (15 cwt. and 20/25 cwt.)

This is a Bishop cam and roller unit as used on many makes of vehicle, both car and commercial, as described in Vol. I. It is only necessary here to indicate that the normal-control model is fitted with the B size while the forward-control utilises the H.

The method of removal of the unit is perfectly obvious, but it will be found that while on the normal control the horn and dipper switch wires can be disconnected at the junction box fixed near the steering gear on the frame, these must be disconnected at the horn and headlamp on the forward control.

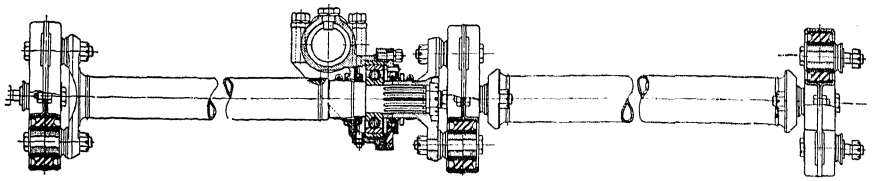


Fig. 4.—PROPELLOR SHAFT WITH LEYRUB COUPLINGS ON N5 AND LN5 MODELS

Brakes (15 cwt. and 20/25 cwt.)

Bendix Duo-Servo brakes are fitted to all four wheels, and all are operated by either foot pedal or hand lever. By means of slotted links interaction between the two systems is prevented.

Failure of any one part of the system will always leave at least two wheels with full braking efficiency.

The brakes themselves are dealt with in Vol. I, but it is stressed that no adjustment is possible by altering the operating length of cables or rods—the brake shoes must be adjusted in the drums.

Should it ever become necessary to detach cables from cross-shaft—as in removal of either front or rear axle—expand the shoes fully in drums on all four wheels and pull on both rods and cables to remove any slack before recoupling. If it is necessary, adjust foot-brake rod until yoke pins can just be inserted, and it will be found that there is just sufficient slack in cables to permit the flexible adjusters to give correct shoe to drum clearance.

N2, N3, N4, AND LN5 MODELS

Transmission

On the 2- and 3-ton models the propeller shaft is of the Hardy Spicer needle-roller type, but on the N5 and LN5, "Layrub" joints are used.

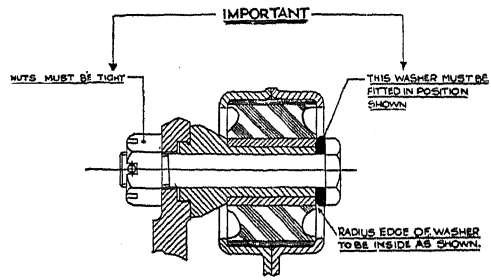


Fig. 5.—WHEN FITTING NEW LEYRUB COUPLINGS

Care must be taken to fit the washer with the radiused edge inside and nuts must be drawn up dead tight.

These latter call for no lubrication, but the bolts must be kept tight, and should be subject to periodic inspection, and if necessary tightened with a spanner having extended leverage.

The bolts are of high-tensile steel and will withstand considerable stress.

As far as the Hardy Spicer type are concerned, full details are given in a separate section.

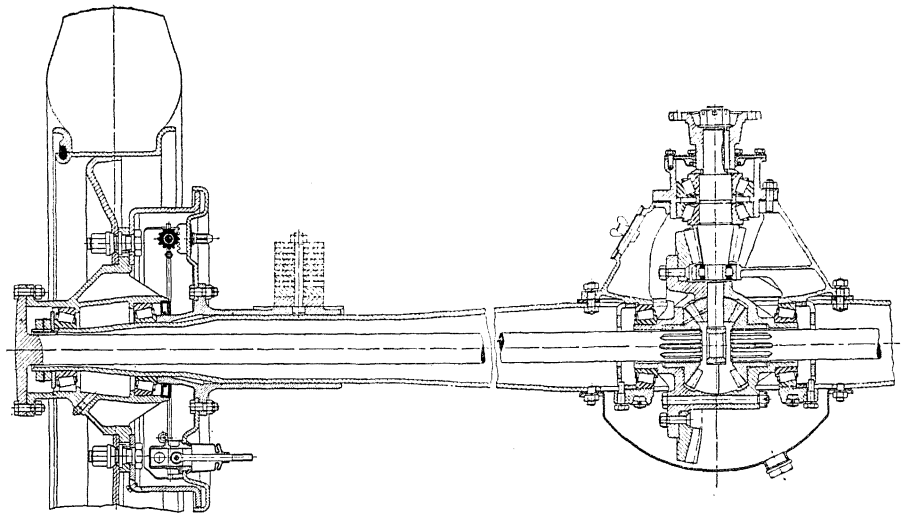


Fig. 6.—ARRANGEMENT OF REAR AXLE-TYPE N2

Rear Axle

The general type of differential unit is similar in all models, although that for the N5 and LN5 is naturally heavier and also incorporates an overload-thrust button.

Axle shafts are fully floating, and after these and also the nuts holding the unit to the banjo have been removed the complete differential unit can be withdrawn forward.

The pinion housing assembly can be removed as a unit, taking care not to lose the shims which are used for positioning between housing and differential carrier.

To dismantle, first remove the coupling locknut and pull off the coupling, which is keyed on to the shaft.

The housing cover and oil seal should then be removed, after which the shaft and rear bearing can be tapped out, leaving the front bearing in the housing.

Shims will also be found between the distance-piece and the front bearing—these are for bearing adjustment.

Bearings should be set so that there is no perceptible end float, but a check should be carried out after the coupling nut is refitted to make sure that the pinion will spin freely.

To adjust the differential bearings, the caps should be slightly slackened and the locking screws removed.

Each adjuster should be screwed in an equal amount until all play is taken up, although the bearings must not be nipped.

The pinion and crown wheel are lapped in pairs and numbered, and

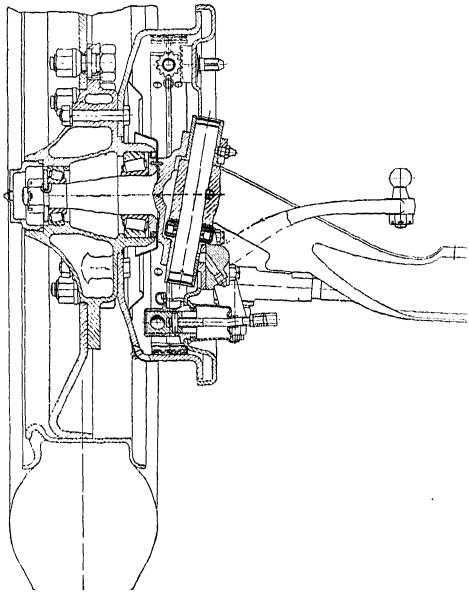


FIG. 7.—ARRANGEMENT OF FRONT-AXLE (TYPE N2)

at no time should a new crown wheel be fitted to an old pinion or vice versa.

If one component is in sound condition it should be returned to the makers, who will supply the necessary new part and lap them together.

When correctly adjusted, there should be approximately $\frac{1}{32}$-in. peripheral movement on the propeller-shaft coupling, with the crown wheel firmly wedged.

Bronze thrust washers are fitted behind the differential box pinions on the N5 and LN5, but not on the lighter models.

Rear Hubs

These are carried on the axle tube by means of opposed taper bearings, and present no special features.

When refitting oil seals, however, extreme care must be taken to see that these are not in any way damaged, either on the face or on the ground edge.

The hub should be examined carefully to ensure that there are no rags or burrs to damage the seal, and a coating of jointing compound should be applied to prevent possible leakage between the outside of the seal and the inside of the hub.

It should be pressed home with an arbor approximately ·015 in. less than the outside diameter of the seal, the sharp edge of the leather being towards the outside of the hub.

Front Axle

The general layout is similar on all types, although individual variations occur in respect of king-pin sizes, hubs, etc.

The king-pin is pressed into the beam and locked by a taper cotter, and it is essential that the king-pin is a driving fit. Oversize pins can be obtained + ·005 in., + ·010 in., and + ·015 in. when required, and where steel bushes are used similar oversizes are stocked.

Renewable bushes are fitted to the stubs, the thrust being taken by a Timken race on the lower face. Should it be necessary to fit new phosphor-bronze bushes, these must be reamered after they have been pressed in

Hubs are carried on opposed taper races and present no difficulty in either dismantling or adjustment.

Steering

Bishop cam-type steering gear is used on all models, varying in size according to chassis type.

All track rods incorporate self-adjusting ball joints, and beyond periodic greasing no attention is required.

In order to assist in resetting the track at any time joints are threaded right and left hand, and it is necessary only to turn the track rod in the required direction after slackening off the clamping bolts at each end. Care must be taken to tighten the clamping bolts securely after the operation. Correct adjustment is $\frac{1}{8}$-in. toe-in. Always use the same point on the rim of the wheel for checking the distance between wheels, both at the front and at the rear.

On the N2, N3, and LN5 models, the side steering tube incorporates oilless cups, but the N5 has self-adjusting joints similar to those used on the track rod.

Brakes

Cowdrey brakes are fitted to all models except the N5, which are Bendix Duo Servo.

We would again stress that it is not possible to adjust the brakes by altering the length of rods or cables, all adjustment being by means of the geared expander in the drum.

If at any time the axles are removed, the brake shoes must be fully expanded in the drum and the cables well stretched, to remove any slackness, and the yoke should then be adjusted so that the clevis can be inserted but without allowing the cables to slack.

Details of the full adjustment are given separately, but we would again remind all users to insist on genuine replacement parts and at no time endeavour to reline existing shoes.

Tyre Pressures (all Models)

The following are the correct tyre inflation pressures for the various models :

8 cwt.—Standard size (5·25 × 16), front 25 lb. per sq. in.; rear 28 to 30 lb. per sq. in. An increase of 4 lb. per sq. in. in the rear tyres is recommended when the vehicle is to be driven fast or with full load.

15 cwt.—6·00 in. × 18 in. front and rear, single tyres, 40 lb. per sq. in. pressure.

N1.—6·00 in. × 20 in. front, 45 lb. per sq. in.; 32 in. × 6 in. truck, rear single, 75 lb. per sq. in.

N2.—6·00 in. × 20 in. front, 45 lb. per sq. in. ; 32 in. × 6 in. R.H.S. Single rear, 90 lb. per sq. in.

N3.—Standard 6.00 in. × 20 in., single front and twin rear, 45 lb. per sq. in. Alternative : 32 in. × 6 in. truck type, single front and twin rear, 75 lb. per sq. in.

N5.—34 in × 7 in., single front, twin rear, 95 lb. per sq. in.

LN5.—Standard 32 in. × 6 in. R.H.S. single front, twin rear, 90 lb. per sq. in. Alternative : 34 in. × 7 in., single front, twin rear, 95 lb. per sq. in.

For vehicles with twin rear tyres, even tyre wear is promoted by changing the position of tyres as follows :

1st position—front wheel.

2nd position—outer rear wheel.

3rd position—inner rear wheel.

REPAIR NOTES ON VAUXHALL CARS

THE REAR AXLE, BRAKES, AND STEERING

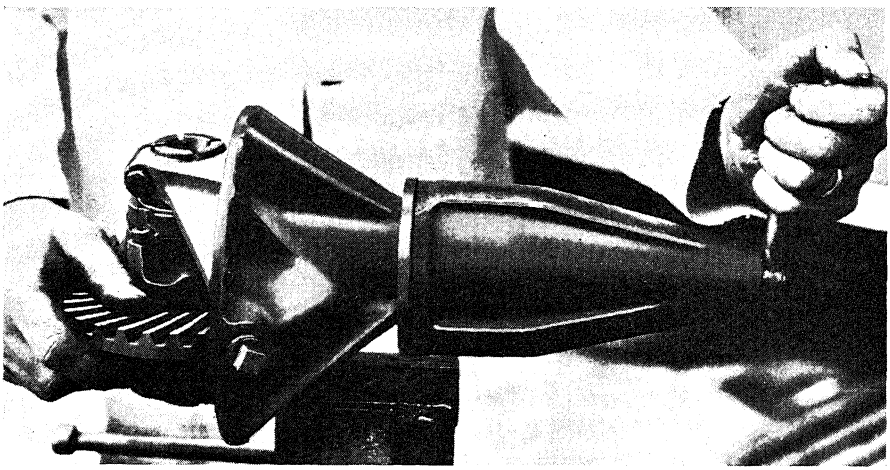


Fig. 1.—REMOVING BEVEL PINION, USING BRITOOL 867/845
If the tool is not available, remove pinion as described in text.

10-FOUR AND 12-FOUR

Rear Axle

THE rear axle of the 10-Four and 12-Four Vauxhall is of the semi-floating type, having spiral bevel final drive gears. The differential, being slightly offset, necessitates the use of axle shafts of different lengths; consequently the right-hand and left-hand shafts are not interchangeable.

Troubles that may be Met With

The following diagnosis will serve as a guide when dealing with complaints of rear axle trouble.

Axle Noisy

Insufficient or incorrect lubricant in axle.
Differential incorrectly adjusted.
Spiral drive pinion and gear teeth worn.
Bearings defective.

Axle Noisy when Cornering

Worn or chipped differential gears.

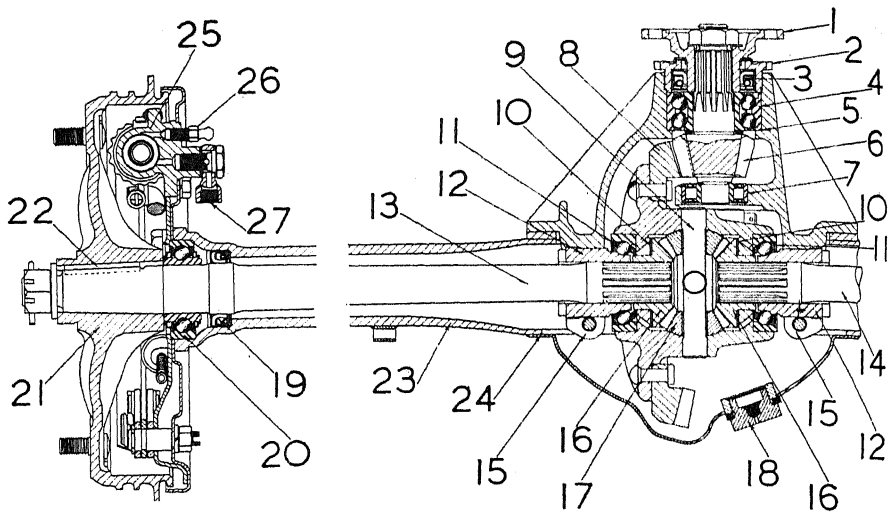


Fig. 2.—SECTIONED VIEW OF REAR AXLE (10-FOUR AND 12-FOUR)

1. Propeller shaft coupling flange. 2. Pinion adjustment locking ring. 3. Pinion oil seal. 4. Pinion front ball race. 5. Pinion adjustment shims. 6. Bevel pinion. 7. Pinion front support roller race. 8. Crown wheel. 9. Differential pinion spider. 10. Differential side gear thrust washer. 11. Differential ball race. 12. Differential ball race adjusting sleeve. 13 and 14. Axle shafts. 15. Adjusting sleeve locking plate. 16. Differential side gear. 17. Differential pinion. 18. Axle filler plug. 19. Axle shaft oil seal. 20. Axle shaft bearing. 21. Rear hub. 22. Key. 23. Rear axle casing. 24. Axle casing. 25. Back cover. 26. Brake cylinder bleeder valve screw. 27. Brake pipe-line connection.

Oil Leakage from Pinion or Past Rear Axle Shafts

Check breather in filler plug.
Worn or defective oil seal.
Axle over-filled with lubricant.

Rear Axle Shafts

To remove axle shafts, take out the split-pin and nut from the end of each shaft. Utilising a hub puller, draw off the rear hubs and brake drums. Disconnect the brake pipe-lines at the union on the rear face of the brake flange plate. Remove the brake backplate attaching bolts; the brake plate can now be lifted away as far as the hand-brake cable allows and rested on the spring. Withdraw axle shaft, using an axle shaft withdrawal tool (Britool No. 867).

Examine the shaft for signs of twist, cracks, or damaged splines.

As the oil seal is pressed into the axle casing it is not possible to remove this without damage, and if fitment of a new seal is necessary owing to leakage, the old seal can be extracted after splitting in half by means of a small sharp chisel.

To replace axle shafts, reverse the operations given for removal

Removing Differential Assembly

To remove the differential assembly, proceed as for the removal of the axle shafts, withdrawing shafts sufficiently to clear the splines of the differential side gears, and disconnect the propeller shaft at the rear universal joint coupling. Remove the eight bolts which attach the differential carrier to the axle casing and draw away the carrier.

Dismantling Differential Assembly

Release the differential adjusting sleeve clamp bolts and unscrew the sleeve out of the casing, then lift away the spiral drive gear and differential cage assembly.

Remove the clamp bolt which secures the bevel pinion adjustment locking plate and extract the locking plate.

Unscrew the bevel pinion adjusting ring out of the differential housing and withdraw the bevel pinion assembly.

When dismantling the bevel pinion assembly the oil seal can be tapped out of the adjusting ring, but as it would probably be damaged in the process a new seal should be used when reassembling.

The outer ring of the race may be left in the differential housing when the bearing is removed, and if so can be easily removed by tapping with a small drift.

Inspecting Differential Assembly

Examine the spiral drive gear and pinion for worn teeth and check the rivets attaching the spiral drive gear to the differential case for slackness. Check the splines of the pinion shaft for wear.

Examine the teeth of the differential pinions and side gear pinions and renew if chipped or worn. Check the bronze washers for scores and wear. The thickness of the washers is ·033–·031 in.

Check the gears for backlash, which should be ·006–·012 in.

Check the planet pinion spindle for wear or pitting.

Wash all bearings in thin oil and inspect for wear or pitted balls and seats. Even slight damage is intensified in the form of noise under operating conditions.

The differential carrier should not be distorted or cracked.

To Reassemble Differential Assembly

The assembly is straightforward, although it is essential that pinion adjustment shims are positioned correctly so that they are nipped between the casing and the outer race of the ball bearing when the locking ring is tightened.

Make certain that both the locking ring and universal joint flange nut are tightened securely, as otherwise a false adjustment may be obtained.

In order to provide the necessary resistance against turning when

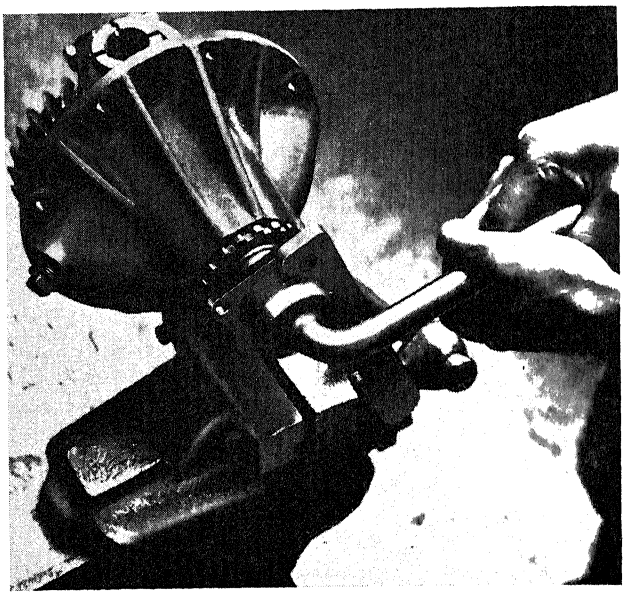


Fig. 3.—METHOD OF USING UNIVERSAL JOINT LOCKING LEVER

tightening the coupling nut, a special tool can be easily made up out of $\frac{5}{16}$-in. mild steel plate. The tool when in use will bear against the vice whilst the nut is tightened (see Fig. 3).

To Adjust the Differential Assembly

With the assembly held firmly in a vice, the gears can be inspected for mesh. Adjustment should be made to obtain full-length engagement of teeth, smooth running, and a backlash between the spiral gear and pinion teeth of from ·005 to ·007 in.

Adjustment for this is obtained by slackening one spiral drive gear adjusting ring and tightening the opposite ring until the minimum amount of backlash can be felt.

When it is apparent that the spiral drive pinion is too far in mesh or insufficiently meshed, it will be necessary to remove the pinion and to remove or add shims. The shims available are of ·003 and ·005 in. thickness ; consequently a close adjustment is possible.

Although it has the appearance of an adjusting sleeve, no adjustment can be made by simply tightening or slackening the pinion locking ring: shims must be added or removed, and the pinion locking ring finally tightened prior to checking the new position obtained.

To withdraw the pinion assembly for the purpose of altering the number of shims, slacken off the adjusting ring and at the same time gently tap the universal joint coupling flange with a copper hammer.

Having satisfactorily completed the adjustment for backlash, that for tooth contact must be made. It is absolutely essential to provide a load to the pinion shaft when rotating the gear.

Without this it has been found that an adjustment can be obtained giving a marking which resembles correct contact, but which invariably results in a noisy axle when assembled.

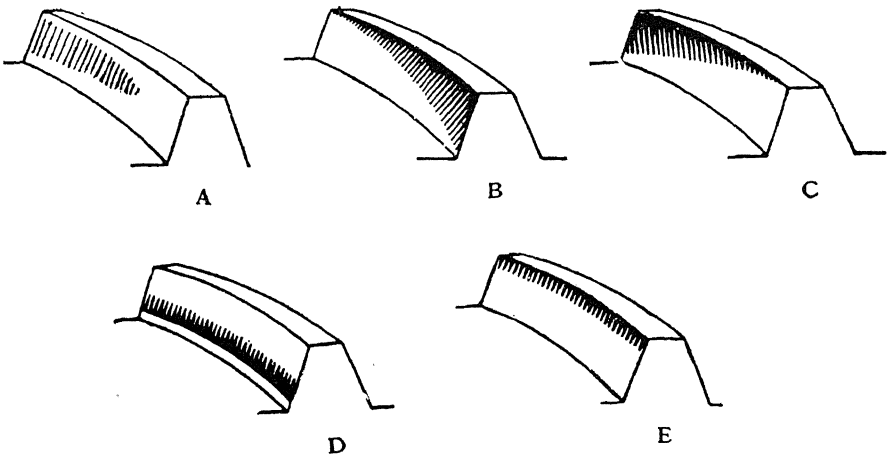


Fig. 4.—SPIRAL GEAR ADJUSTMENT DIAGRAM

A.—Correct contact. B.—Heavy contact on inner end of tooth—correct by moving spiral drive gear towards pinion, retaining specified backlash, if necessary, by moving pinion outwards. C.—Heavy contact on inner end of tooth—correct by moving spiral gear away from pinion, maintaining the backlash by moving in the pinion if necessary. D.—Heavy contact along root of tooth—correct by moving pinion outwards. E.—Heavy contact peak of tooth—correct by moving pinion inwards.

A sufficiently effective load can be obtained if a 4-in.-diameter circular plate having rounded edges be turned and drilled for bolting up to the universal joint coupling flange. This provides a comfortable grip for the hand.

A brass plug with a $\frac{5}{16}$-in. S.A.E. thread should be screwed into the tapped drilling provided in the differential casing, so that the side and planet gears cannot rotate. In order to turn the spiral gear, a handle should be made up and inserted to engage with the splines of one of the differential side gears.

The teeth of the spiral drive gear should be given a light coating of engineer's marking blue in two or three positions around the gear and covering at least six teeth in each place.

The gear must be rotated in both directions. To ensure quiet running and minimum wear, the bright marking which compares with the shaded area at " A," Fig. 4, should be obtained.

The markings should appear in this form on both sides of the teeth—i.e. on " drive " and " over-drive." It will probably be found that the bright markings will not conform to " A " at the first attempt ; they will probably approximate to the form of one of the other markings shown in Fig. 4. In this case adjustment must be made as indicated against the diagrams until the marking at " A " is obtained, together with backlash within the limits ·005–·007 in.

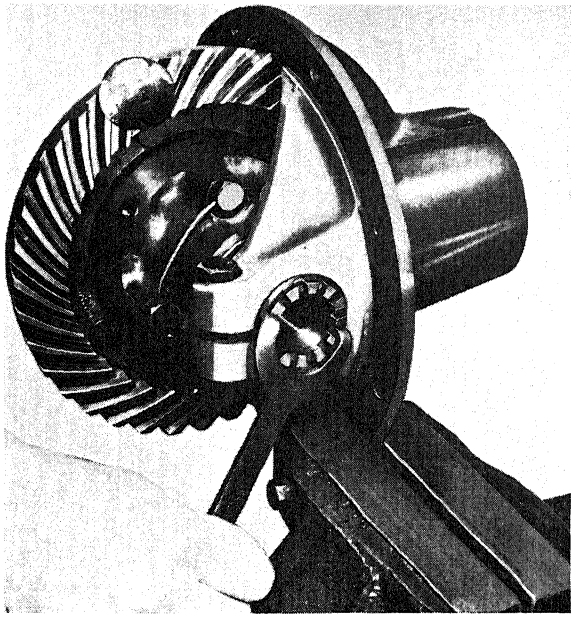


Fig. 5.—DIFFERENTIAL SIDE BEARING ADJUSTMENT
Note the plasticine fixed to the outer edge of the spiral bevel gear

Throughout these checking operations do not omit to apply pressure to the hand grip on the drive pinion.

The final adjustment is that of the differential thrust races. This is extremely important and has a distinct effect on the resultant quietness of gear operation.

Remove the brass plug from the differential casing and the hand-grip from the universal joint coupling.

Withdraw the spiral drive pinion. Fix the differential carrier in the vice, holding it by one of the webs so that the spiral bevel gear is in the vertical plane.

Affix half an ounce of plasticine to the outer edge of the spiral bevel gear (Fig. 5). The use of this is to provide an accurate guide for testing the adjustment of the differential thrust races.

The sleeves should be tightened only to an extent that will allow the weight of the plasticine to slowly turn the gear. This test should be carried out in both directions of rotation and in several positions.

This operation does not affect the previous meshing adjustment, inasmuch as the adjusting ring rotation required to obtain this final setting will be extremely small; when the foregoing is satisfactorily completed, tighten the sleeve-clamp bolts, replace the spiral drive pinion, and thoroughly tighten the locking ring.

Lock the latter in position with the locking plate, which will be seen to be formed with a single and double tongue, so that movement of half a castellation is sufficient to allow engagement. Slide on the coupling, thoroughly tighten the nut, and turn up the locking washer.

To Renew Spiral Drive Gear

The spiral drive gear and pinion are serviced in matched pairs, as it is not satisfactory to attempt to fit a new pinion to a worn gear or *vice versa*.

Remove the spiral drive gear rivets by drilling through the head. A $\frac{1}{4}$-in. drill will be required. Do not attempt to take off the heads of the rivets with a chisel.

Drill through from the flat head of the rivet in order to assist the operator to keep in the centre of the rivet shank. In order to avoid damage to the differential case holes and when drilled through sufficiently to weaken the rivet heads, cut off the shell of the heads with a chisel and punch out the rivets.

After the gear is removed, centre the case in a lathe and check for run-out. A maximum of ·002 in. is allowed, and if in excess of this, true up.

Clean all burrs from the rivet holes and the faces of the case and the gear, bolt the gear tightly to the case, using four well-fitting bolts.

The riveting must be done cold in a suitable press.

The spiral drive gear is secured to the differential case by means of the four bolts already mentioned, whilst the first few rivets are inserted into position. Rivet on alternate sides of the circumference, so that it will not be drawn out of truth.

The rivet heads naturally must be formed on the casing side and must not extend for more than $\frac{5}{8}$ in. from the face of the ring gear.

On completion of the riveting, the back face of the spiral drive gear should be checked with a dial gauge for run-out, which must be within ·0035 to ·005 in.

Rear Springs

The rear springs are of the semi-elliptical type. Rollers are fitted to prevent squeaks developing, two of these being threaded in order to act as bolts to which the two spring clips are secured by castellated nuts and split cotter pins.

The spring is attached to the axle by U bolts, special rubber insulators being interposed between the upper and lower clamp plates.

The special bumper is also clamped to the top of the axle casing by the U bolts. At both the front and rear ends of the spring the top leaf is turned back to form an eye into which a " Silentbloc " bush is pressed and retained by peening over in four places. It will be noticed that the bent-over portion of the eye is in tension and clear of the flat of the spring leaf.

After removing the springs, examine the spring leaves for signs of cracks and check the assembly for camber, which should be $\frac{1}{8}$ in. reverse.

The " Silentbloc " bushes should be renewed if perished or in any way deteriorated. These can be easily renewed by pressing out the old bush assembly or alternatively by forcing out with a suitable drift.

The new bush should then be pressed into position and peened over in four places.

When springs are reassembled after dismantling, fit the nuts to the

shackle bolts, but do not fully tighten. The rear of the car should then be bounced two or three times to allow the " Silentbloc " bushes to take up the correct position, after which the nuts can be tightened and split-pinned.

Rear Shock Absorbers

The rear shock absorbers are of the single-acting hydraulic type.

All service work on the rear shock absorbers (with the exception of topping-up) must be carried out with the absorber removed from the car.

When servicing, examine for slackness of the shaft in the casing and also for end float on the cam lever. This should be ·025 in. maximum.

Other than attention to the piston, piston return spring and relief valve, it has been found that the cost of labour and material in reconditioning these shock absorbers is equal or more than the price of new assemblies.

The pistons and cylinder walls must be free from scores. Check also the pistons for wear on the face which contacts the inlet valve seating. The valve cannot be dismantled, and therefore any question as to its efficiency can only be satisfactorily answered by replacement.

LIGHT SIX, 12 H.P. AND 14 H.P. (MODELS D)

Removing Rear Brake Drum

To avoid risk of damaging the brake shoes, slacken off the adjustment. Remove the three countersunk screws attaching the brake drum to the flange of the axle shaft, when the drum can be pulled over the wheel attaching bolts by hand. Two tapped holes in the brake drum permit the use of an extractor if necessary.

To Replace

The attachment screw holes in the brake drum are unequally spaced, so that the holes in the drum and the hub must be brought into line before the drum is passed over the wheel attachment bolts.

If the brake adjustment has been released, do not omit to readjust the brakes.

Removing the Axle-Shaft Assembly

Slacken off the six nuts and lock washers which attach the retaining plate to the casing. The nuts can be completely removed, utilising the special hole for this purpose provided in the axle-shaft flange.

In most cases it will then be possible to draw the axle-shaft assembly out of the housing, but if the fit of the ball race in its housing prevents easy withdrawal a drag of suitable type (Britool Drag No. 882) will be required.

A shrinkage fit holds the retaining collar on to the axle shaft.

If it is required to remove the collar, it will be necessary to turn it off in a lathe. An extractor will be required to remove the bearing when the other parts can be removed and the axle shaft and component parts are ready for inspection.

Renew the oil-retaining seal if worn or, if prior to dismantling, oil leakage has been evident.

Make certain that the surface of the retainer plate is perfectly flat, and also that no slight irregularities prevent it from seating.

To Reassemble

Carefully affix the paper gasket to the oil deflector, using a good jointing compound. Thread the oil deflector and retainer assembly on the shaft and then press the bearing on to the shaft followed by the special spring washer. As the bearing retaining collar is a shrunk fit on the shaft, the new collar must be brought to a heat of 300–350° C. (dark blue coloration) before being pressed into position. Note that these parts must be assembled solidly on to the shaft, no side play of the bearing being permissible.

Allow the collar to cool off in the air and lubricate the bearing.

To Replace

Insert the shaft and engage the inner end splines with the differential gear. Locate the retaining plate squarely in the end of the housing and tighten the attachment nuts evenly and thoroughly.

Differential Carrier Assembly

To remove, see preliminary instructions for the 10-h.p. model.

Assist the carrier from the housing with the hands and the application of light blows with a lead hammer.

The differential carrier bolts will remain fixed in the housing, and care must be taken to prevent the bolt threads being damaged as the carrier is drawn off.

Before *dismantling* the differential assembly the work will be considerably simplified if the differential carrier is mounted on the bench on three support tubes and long bolts, which, if made up for the purpose, will be found of considerable use whenever differential adjustments are being made.

Mark the differential carrier caps to ensure that they are refitted correctly.

On vehicles which have covered an appreciable mileage, all four differential gears should be either suitably marked or placed on the bench in such a manner that they may be replaced in the same position as they previously occupied.

If it is necessary to remove the differential side bearings, a drag will be required.

To inspect the differential carrier assembly, see instructions for the 10 h.p. model.

When replacing the differential-carrier assembly, always fit a new gasket between the differential carrier and the axle housing.

To Adjust Spiral Drive Gear

It is difficult to lay down a specific rule for controlling the backlash between the spiral drive pinion and the gear. However, the quietest running and the longest life of the gears will be obtained if this backlash is maintained within the limits of ·004 and ·008 in. Check this clearance by the insertion of feeler gauges between the engaged teeth.

Having adjusted the pinion by means of the outer and inner adjusting sleeves provided to give as near as possible full tooth bearing, proceed with the adjustment in the following way :

If the backlash is too great, slacken back the adjusting ring several turns and the whole of the differential assembly by tightening the opposing adjusting ring. This brings the spiral drive gear into closer mesh with the pinion.

This operation is naturally reversed if the gears are too tightly in mesh, i.e. the adjusting ring on the back side of the spiral drive gear is unscrewed several turns and the other ring adjusted up until the requisite backlash is obtained.

The final operation is very important.

The adjusting ring which was first screwed back several turns may now be brought up until it contacts with the outer races of the bearing and induces this race to turn with it. This is the correct adjustment, and both adjusting rings are therefore locked in this position by the lock. The differential bearing can now be thoroughly tightened.

To Renew

The differential side bearings are removed by means of an extractor.

Before attempting to fit a new spiral drive gear, the face of the differential case must be checked for running true. If this face runs out of truth more than ·003 in., skim it up in a lathe.

The spiral drive gear is bolted to the differential case with four bolts whilst the first few rivets are inserted into position.

Check with a dial indicator on the back face of the spiral drive gear after fitting, allowing a maximum run-out of ·003 in.

N.B.—New spiral drive gears are always supplied together with a matched spiral drive pinion. Never replace one without the other.

Carefully remove any splinters of metal which may have broken away from the rivet heads during riveting.

Refit differential side bearings.

In addition to the foregoing, see also renewal instructions for the 10-h.p. model.

To Inspect

Examine the thrust bearing for wear after washing with thin oil (not paraffin).

This bearing must not have the slightest slackness, as it is responsible for carrying the whole of the thrust load, as well as a proportion of the journal load, the combined factor of which is frequently very high.

Also examine the cage of this bearing for signs of fracture, due to wear, and replace the bearing if any such evidence exists ; any breaking up of the cage of this bearing will result in pieces dropping into the axle and causing damage, which may be of serious consequence.

Examine the teeth of the pinion and renew if excessively worn.

N.B.—Spiral drive pinions and gears are supplied in matched pairs, and a new pinion should never be fitted without renewal of the spiral drive gear.

Examine the oil seal fitted in the pinion front adjusting sleeve and renew if the leather is excessively worn or hard.

Check the pinion rear bearing for wear.

Before replacing the outer adjustment sleeve of the pinion, the oil seal incorporated in this should be soaked for two hours in a light mineral oil at a temperature of approximately 100° F.

Steering Gear

The steering gear from chassis Nos. DX 655401 and DY 514001 onwards is Burman Douglas. Particulars of adjustment of this type will be found in Vol. I. Chassis prior to the above numbers was fitted with worm and sector form of steering having the following adjustments.

To Adjust End Float

At the back of the steering box will be found an adjusting screw, secured by a locking nut. This screw is for the purpose of adjusting the end float on the drop-arm shaft. Loosen the locknut and tighten the screw until contact is made with the drop-arm shaft, when the locknut should be retightened.

To Adjust Backlash between Worm and Sector

A bolt and sleeve secure the drop-arm shaft housing to the steering box. The sleeve is eccentric, enabling adjustment to be made to overcome the backlash between the worm and the sector. The sleeve is provided with a hexagon nut.

To adjust, turn the bolt in a clockwise direction to decrease, and an anti-clockwise direction to increase, the backlash. The bolt should be turned by means of a spanner until, when gently turning the steering wheel backwards and forwards, a tight spot can be felt just as the front wheels pass the straight-ahead position. Whilst carrying out this operation the sleeve hexagon should be held stationary with another spanner.

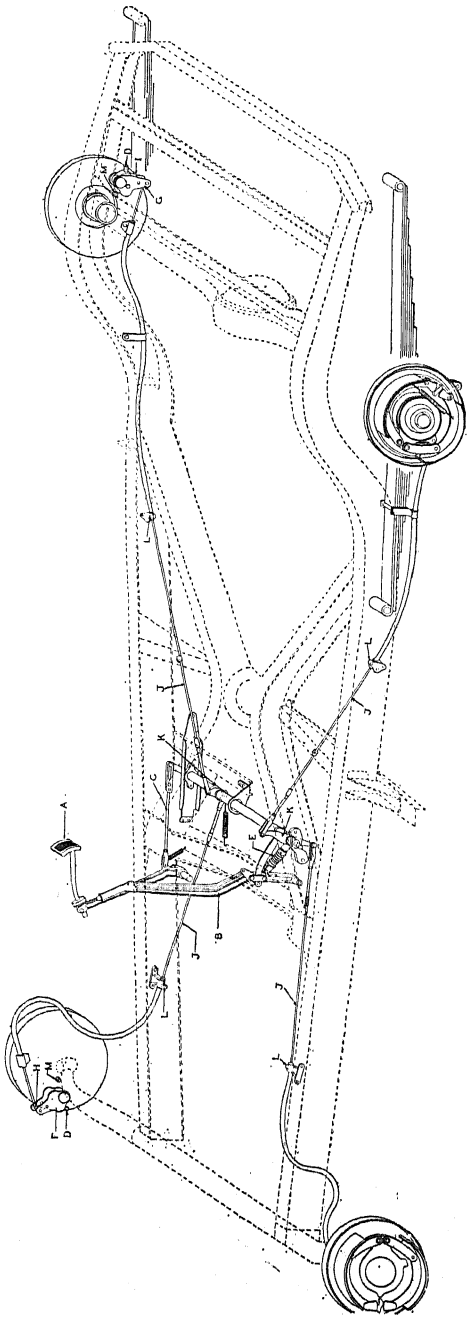


Fig. 6.—FOUR-WHEEL BRAKE LAYOUT (LIGHT SIX, 12-H.P. AND 14-H.P.)

If it is not possible to take up the backlash sufficiently by means of the eccentric bolt, turn back the bolt to a position which gives the greatest degree of backlash, and then rotate the sleeve until most of the backlash is taken up. Very fine adjustment can then be made with the bolt.

When reassembling the steering box after dismantling, the drop arm must be replaced on the drop-arm shaft in the correct position. For this purpose lines will be found marked both on the drop arm and the shaft, which should coincide.

To Adjust End Float in the Steering Column

Adjustment for end float of the inner column is provided by an adjusting plug, which will be found located between the steering box and the outer column.

To carry out this adjustment, slacken off the column support clamping bolt and the clamp bolt on the top of the steering-box casing, after which the adjusting plug nut is screwed down until it is possible to spin the wheel freely, but without any trace of binding in the column.

Adjusting Braking System

The four-wheel brakes on the Light Six, 12-h.p., and 14-h.p. Models D are

of the mechanically operated semi-servo type, servo action being obtained by a link arrangement attached to each shoe, by which full contact of the shoes with the drum is obtained. On applying the brakes, the rotation of drum itself reacts upon and increases the pressure of the shoes to drum.

When possible, it is better to lift all four wheels when carrying out adjustments. All the four must be given attention.

Set the hand-brake lever (B) (Fig. 6) in the fully off position and screw the adjusting screw (D) of each brake until the shoes are binding hard on the drums. Tap the centraliser bolts (M) to ensure that the centralisers are free to move. This operation centralises the brake shoes in relation to the drum, after which the brake-shoe adjustment screw (D) must be unscrewed just sufficiently to allow the drums to rotate freely after application of the brake pedal.

On completion of these adjustments, the vehicle should be tested on the road, and if it is found that the braking is uneven, slacken off the adjustment screw (D) of the brakes which bind the harder until even braking is obtained.

Resetting the System

The brake-operating system is correctly set when the car is new. Do not interfere with this setting, therefore, unless the whole system has previously been disturbed or the vehicle has sustained accident. Never shorten the brake-operating cables to compensate for wear on the brake-shoe liners. However, if the system has been disturbed, the following work will be required.

Disconnect the front- and rear-brake cables from the levers (K) on the cross-shaft and also the foot-brake pull-rod (C). Set the foot-brake pedal in the fully off position up against the toe-board and adjust the brake-pedal pull-rod (C) so that when connected there is no slack in the hand-brake thrust link (E).

Set the front- and rear-brake cam levers (F) and (G) against their stops (H) and (I), tap the centraliser clamp bolts (M) to make sure that the centralisers are free to move, and tighten the adjusting screws (D) until the shoes are binding on the drums.

The front- and rear-brake cables should now be adjusted until the clevis pins can just be inserted through the cable yoke ends and the levers on the cross-shaft without slack in the cables, yet without lifting the levers (F) and (G) from the stops. Slacken off the adjusting screws (D) until the road wheels will revolve freely. The final setting should be made on the road or brake testing machine.

The maximum allowable drum ovality is ·006 in.

VAUXHALL 25-H.P. (MODEL G)

Removing Rear Axle Shafts

Remove the axle housing inspection cover. Take out the planet pinion spindle lockscrew (14) (Fig. 7) and withdraw the spindle (16) so

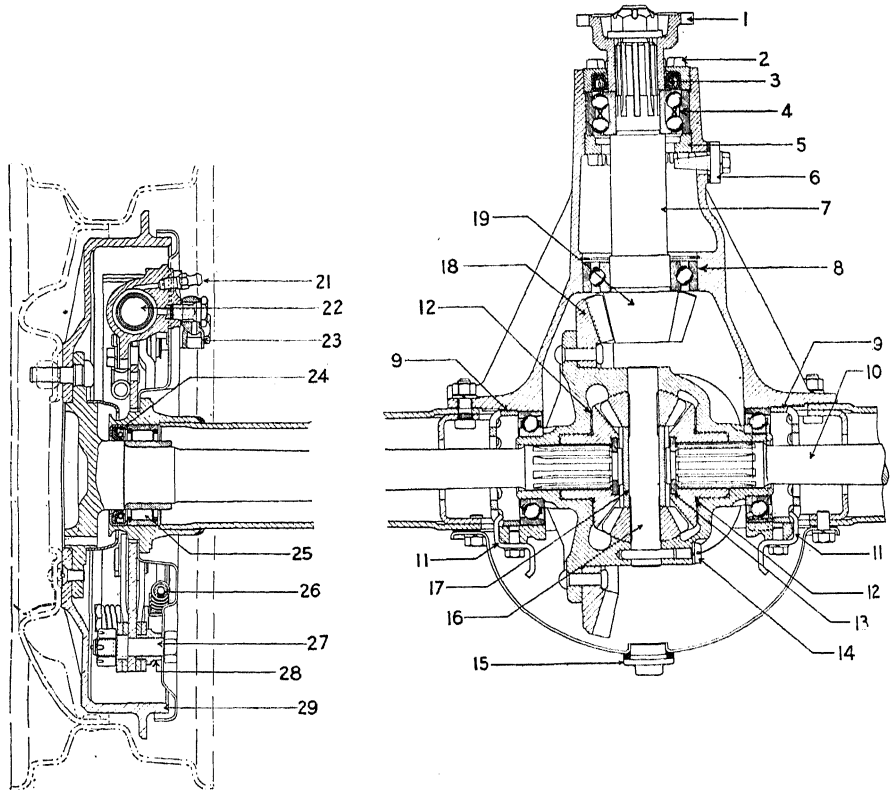


Fig. 7.—SECTION OF REAR AXLE

1. Propeller shaft coupling flange. 2. Pinion front adjusting ring. 3. Oil seal. 4. Double row ball thrust bearing. 5. Pinion rear adjusting ring. 6. Adjusting ring locking plate. 7. Pinion shaft. 8. Ball bearing. 9. Differential carrier adjusting sleeve. 10. Rear axle shaft. 11. Spiral drive gear adjusting sleeve locking plate. 12. Differential side gear thrust washer. 13. Axle shaft retaining collar. 14. Planet pinion shaft lock screw. 15. Filler plug. 16. Planet pinion shaft. 17. Axle shaft spacer. 18. Spiral drive gear. 19. Spiral drive pinion. 20. Spring saddle. 21. Brake cylinder bleeder screw. 22. Brake cylinder. 23. Brake cylinder pipe union. 24. Oil seal. 25. Roller bearing. 26. Hand brake operating cable. 27. Brake shoe anchor link bolt. 28. Brake shoe anchor link bolt spacer. 29. Brake drum.

that the axle shaft spacer (17) can be removed Push inwards the brake drums in order to release from the counterbores in the side gear the horse-shoe washers, which can then be pulled from the grooves in the axle shafts. The shaft with brake drums attached can now be withdrawn from the housing.

Where wear on the brake drums has been sufficient to form a groove, the shoes are likely to bind unless the brake adjustment is first slackened off.

Remove the drums by taking out the three retaining screws.

To Inspect

Inspect the condition of the oil seals. Renew the seals if, prior to dismantling, there were signs of oil leakage. These seals are held in position on the ends of the axle housing by centre punch-marks. The easiest method for removal is to clean off the punch-marks and then to use a drag and pull out the axle shaft bearing, which will bring with it the seal.

Examine the axle shaft spacer for wear. Unless the spacer permits a minimum amount of end float of the axle shafts, a knock will result. There are three sizes of spacer available.

Part No.	1036667F . . .	1·160/1·161 in.
	1036667H . . .	1·164/1·165 in.
	1036667K . . .	1·168/1·169 in.

Intermediate sizes may be obtained by carefully rubbing down, using emery paper and a surface plate, or by grinding.

To replace, reverse the operations given for removal.

Differential Pinions and Side Gears

Check the bronze washers for scores and wear. The thickness of the washers is ·032–·031 in.

Check the gears for backlash which should be ·006 in.

To Reassemble

When assembling the side bearings to the differential casing, before pressing on to the spigots make certain that these are free from burrs. It is important to assemble them with the side marked THRUST outwards.

To Adjust

Adjustment should be made to obtain a backlash between the teeth of from ·004 to ·008 in.

If it is necessary to move the spiral drive pinion in or out, either the front or rear locking ring (Fig. 7) must be slackened off, according to the direction in which the pinion is to be moved, and the opposite ring tightened.

Similarly, the spiral drive gear can be adjusted, but in this case a final adjustment is necessary. The adjustment ring which was first screwed back when the final meshing adjustment was made must now be brought up until it contacts with the outer race of the bearing and induces this race to rotate with it. *Immediately* this occurs, the adjustment is correct and the adjustment rings must be locked into position by the ring locks and the bearing-cap bolts tightened.

Having obtained smooth running with correct backlash, it is desirable to check the contact of the teeth.

Proceed according to the instructions for the 10-h.p. model.

Adjustments for teeth contact must be made as indicated against the diagrams until the marking at A is obtained, together with backlash within the limits of ·004·008 in. The gear teeth must be "re-blued" before each test. When a satisfactory result is obtained, remove the turned-down joint and continue with the reassembly operations.

For *renewing* the spiral drive gear, see instructions for 10-h.p. model.

A later article in this volume deals with the 14-h.p. "J" model Vauxhall and with the changes occurring on later 10-Four and 12-Four models.

CELLULOSE REFINISHING FOR THE MOTOR TRADE

By H. J. CURTIS



Fig. 1.—APPLYING THE FILLER COAT
Note masking paste on window to prevent material adhering to glass.
(*By courtesy of Provincial Sheet Metal Works, Cheam*)

THE aim of this article is to give advice, in a very condensed form, and as many hints and tips as possible to the cellulose operators in the motor-car cellulose refinishing business. The subject covers a very large field, so the writer will deal with it as briefly as possible, and right to the point in many cases, using simple terms which may be readily understood by beginners and experts alike.

The Spraying Equipment Required

Before dealing with the various methods of application, some advice on the spraying equipment is necessary. There are various spray plants on the market, many of which are of the small "touch-up" variety.

Whilst these small plants may be quite suitable for work such as touching-in small spots on wings, panels, etc., they are most certainly not suitable for complete refinishing. It is advisable, therefore, that anybody contemplating an entry into the cellulose business should start well by purchasing the right type of plant.

Position of the Exhaust Fan

The cellulose operator is usually interested to know whether the continued use of these materials is in any way detrimental to his health. All paint material, whether cellulose or otherwise, if breathed in sufficient quantities, would have undesirable effects. Providing, however, that reasonable precautions are taken, such as correct ventilation and exhaust-fan arrangements, there is no likelihood of any ill results. With regard to the exhaust fan which must be fitted in all spraying-booths and paint-shops, the necessity of having this fitted near the floor is often overlooked. The reason for this low position is that vapour (or cellulose fumes) is approximately three times heavier than air. Thus a fan fitted several feet from the floor would fail to exhaust the fumes in a satisfactory manner. The law, under the Factory Act, says that the air in a paint-shop must be changed thirty times an hour. In the same way that the fan protects the health of the operator, it also reduces the risk of fire and explosion. It must be remembered that these materials are highly inflammable in nature, and a "No Smoking" notice should be prominently displayed.

Avoiding Trouble with Materials

It should here be stated that it is a great mistake to mix various manufacturers' material, i.e. to use one make of primer, another make of filler, etc. Manufacturers spend many thousands of pounds annually on research work. To destroy deliberately this valuable information, which is given free to users, is foolish, to say the least of it, and is the frequent cause of trouble. Remember, when carrying out the work, to complete it with one manufacturer's products.

METHODS OF REFINISHING A CAR

For the benefit of those whose knowledge is very limited, the following are the usual methods by which a car is refinished from the bare metal upwards. There are two methods by which a car can be refinished. The first is by using oil-base undercoats, followed by the cellulose colour. The second by using cellulose-base undercoats, also followed by cellulose colour. The former method is usually recommended, due to the fact that oil-base materials have better adhesion, more elasticity, and better filling properties, but the drying times are very much longer. However, as speed is of such paramount importance to-day, the use of cellulose undercoats is almost universal in the refinishing shop.

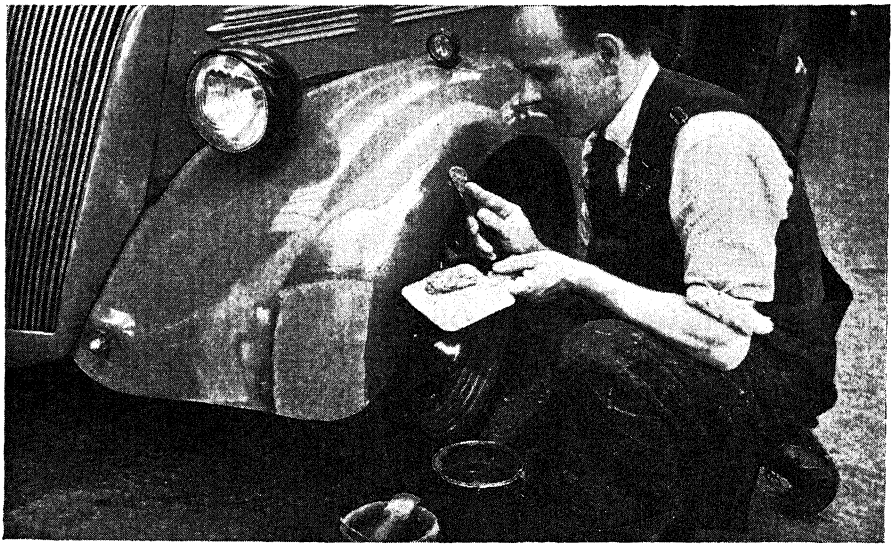


Fig. 2.—FILLING AND STOPPING REPLANISHED WING PRIOR TO RUBBING DOWN AND FLATTING
(*By courtesy of the Provincial Sheet Metal Works, Cheam*)

A comparison of oil-base and cellulose undercoats is as follows :

Oil Primer
Drying time 12 hours.
Oil Filler
Drying time 4 hours between coats.
Oil Stopper
6 hours.

Cellulose Primer
Drying time 30 minutes.
Cellulose Filler
Drying time 30 minutes between coats.
Cellulose Stopper
1 hour.

Removing Old Paint

In the first place, all the old material should be removed by one of the many paint removers on the market. Care should be exercised in the cleaning down of the body after stripping. A good method is to wash off with petrol to remove any trace of the paint remover. Failing to do this thoroughly, trouble may result in the non-drying of the subsequent coats applied.

Dealing with Rust Spots

Should any rust spots show themselves, treat these with rust remover. Allow this to remain for a few minutes, then scour the surface with emery and finally wash off.



Fig. 3.—FRONT VIEW OF CAR, MASKED AND ALREADY SPRAYED WITH FILLER
The operator is working with rubber pad covered with abrasive paper to ensure flat surface, prior to first coat of cellulose enamel.

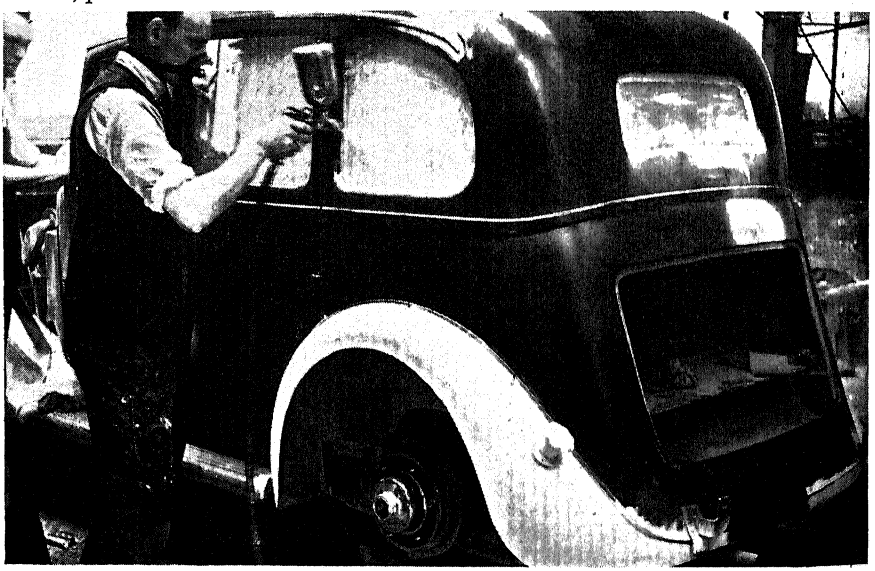


Fig. 4.—OPERATOR APPLYING FIRST COAT OF CELLULOSE ENAMEL TO PANELS OF CAR
(By courtesy of the Provincial Sheet Metal Works, Cheam)

Spraying the Filler Coats

The next step is to spray the primer coat. Having arrived at the spraying stage, it should be noted that all cellulose materials are applied at a pressure of approximately 55 lb. This pressure can be varied to the extent of a few pounds either way, with a minimum of 45 lb. Filler coats are now applied, the number of coats depending entirely on the condition of the body. With modern panel work, three coats are usually sufficient.

After the First Filler Coat—Stopping

After the first of these has been applied, it is necessary to fill in all dents and imperfections with knifing stopper, remembering that this must never be heavily applied. Should a dent be deep, two or more spreads must be used.

Wet-sanding

Now apply the second filler coat and successive coats, as deemed necessary, leaving the last coat overnight to harden out thoroughly before wet-sanding.

Applying the Colour Coats

The colour coats are now applied ; three coats, generally speaking, being sufficient. After the last of these, the job should be allowed to remain for four hours, and then wet-sanded with a fine grade of abrasive paper.

Eliminating Sanding Scratches

Dry off thoroughly and overspray with a coat of thinners, to which may be added a small percentage of the colour. This is to eliminate slight scratches caused by the sanding operation.

Polishing

Some hours should be allowed to elapse before polishing with smoothing compound, and the job is finally brought to a high lustre by the use of a liquid or wax polish. Hints on polishing are given on p. 200.

REPAIR WORK

The principal work in the refinishing shop to-day, however, is that of carrying out repair work, due to accidents. Difficulties are experienced here, principally due to the fact that the bigger mass-production manufacturers are using materials other than cellulose for finishing their bodies. Synthetic stoving enamels are largely used to-day for this purpose, and unless the refinishing shop is equipped with stoving lamps which will enable them to use a similar material, the use of cellulose is the only satisfactory alternative. It is not always possible to apply cellulose direct to these baked surfaces without experiencing trouble in the form

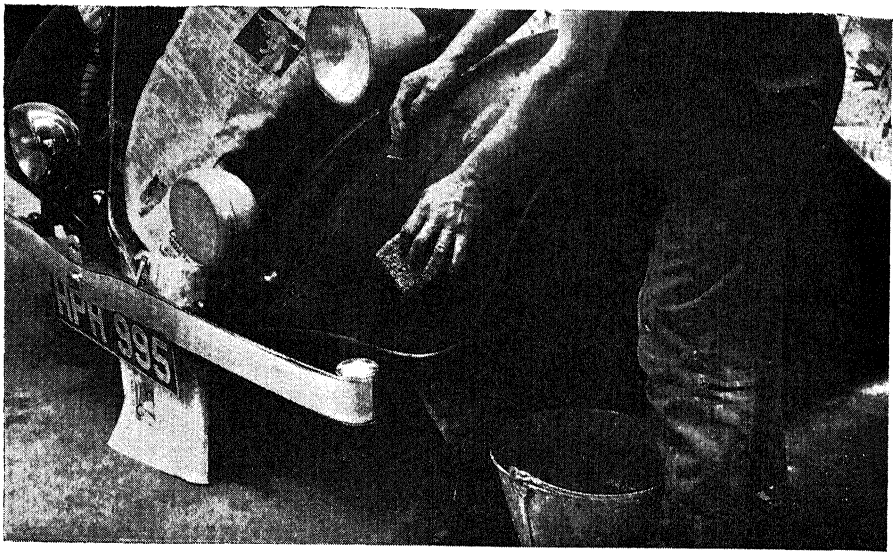


Fig. 5.—FLATTING DOWN WING WITH ABRASIVE PAPER IN PREPARATION FOR FINAL COAT OF CELLULOSE ENAMEL

(*By courtesy of the Provincial Sheet Metal Works, Cheam*)

of boiling up or splitting. So the most essential thing is correct preparation, which can be effectively carried out with the use of cellulose surfaces. These materials will seal or isolate the stoved surface, thus preventing the troubles previously mentioned.

Applying Cellulose to Enamel

To carry out a repair of the above nature, first clean the affected panel or wing, etc., with petrol to remove any polishes or grease. Then wet-sand the fracture, extending to an inch or so all round. Spray one coat of surfacer and then stop up if necessary. This is followed by two or more coats of surfacer. Allow the final coat to harden, and wet-sand with abrasive paper. Now apply the colour coats, extending each coat slightly farther than the previous one. Proceed with the smoothing and polishing operations as previously described.

Refinishing Over Old Cellulose

Whilst on the subject of repairs and troubles ensuing from the use of cellulose over synthetic surfaces, this trouble and also that of refinishing over old cellulose are experienced in the paint-shop. Even experienced operators are troubled to a great extent by this, and in many cases do not know why it happens or how to overcome the trouble. What actually happens is that the film of cellulose loses its elasticity through exposure,

and therefore goes hard and brittle. When the new lacquer is applied over this, it has a strong solvent action on the old film, thereby softening it, and in the drying it is unable to give or flow to the extent of the new lacquer, which causes it to split. The effect on the finished job is that of innumerable scratch-marks.

To overcome this trouble it is necessary to seal up the old film, and for this purpose a cellulose surfacer must be used in which the solvent is of a slower-drying type. A surfacer of this kind will not have such a fierce paint-remover action as the ordinary material, and will only penetrate the surface sufficiently to get a good key and will dry off slightly slower. It will be found that old cellulose surfaces treated in this manner will not give trouble.

The surfacer mentioned must not be confused with the ordinary type of cellulose primer surfacer, although it is naturally similar in many respects. The material must be very elastic and flexible, so that stresses set up by the old lacquer coats are absorbed by it and not transmitted directly to the new lacquer. It contains special ingredients together with a fairly high percentage of pigment, which definitely acts as a buffer coat between the old and the new cellulose surfaces.

The most important point to note is that in applying this material over an old lacquered surface, it is always advisable to apply a mist coat

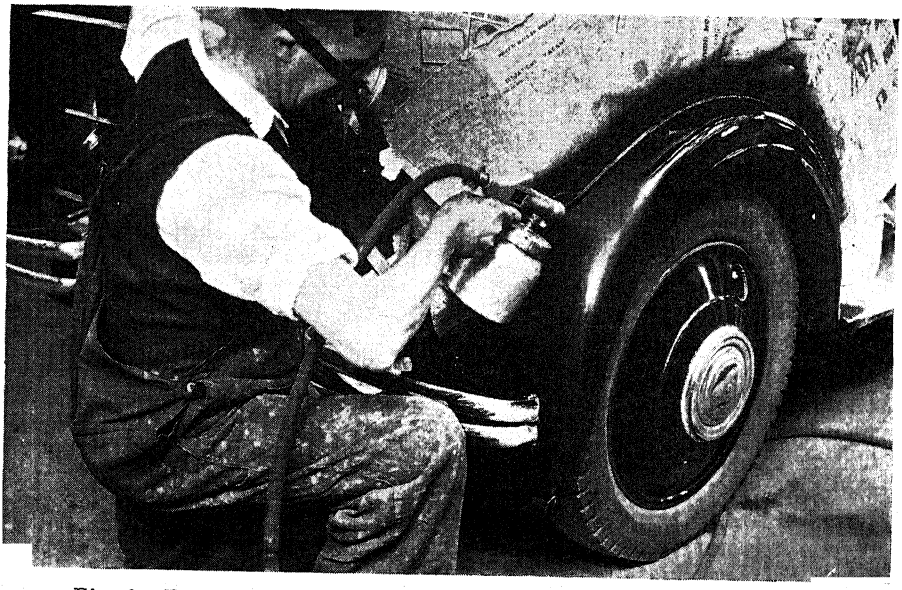


Fig. 6.—FINAL COAT OF CELLULOSE ENAMEL BEING SPRAYED ON WING

Note masking on panels to prevent cellulose from being sprayed on panels which are of a different colour. (*By courtesy of the Provincial Sheet Metal Works, Cheam*)

and then follow with a normal coat. It should further be added that when the material is going to be flatted, a further coat will be necessary, otherwise the flatting operation will remove this protecting or buffer coat, allowing the finishing coats of lacquer to penetrate into the old lacquer resulting in the original trouble.

Cellulosing Wood

The foregoing remarks have applied to the use of cellulose on metal, and although the necessity of applying cellulose to wood on the modern motor-car is almost extinct (owing to all-steel bodies), at the same time the spray-shop is sometimes called upon to do so. It must always be borne in mind that the attendant risk of the cellulose cracking and coming away wherever there is a joint or screwed-on moulding is considerable. Furthermore, it will flake off to the bare wood. This is sometimes due to unseasoned wood or to the fact that the strain and vibration set up by the moving vehicle causes the wood to whip.

Therefore, whenever it is necessary to cellulose the external wood parts on a body, always use oil-base undercoats, which will allow for a slight amount of movement to a greater degree than would the harder cellulose undercoats.

A good tip, whenever cellulose on wood is undertaken, is to take equal parts of linseed oil and turpentine, mix together, and rub hard into the wood with a piece of coarse rag, any surplus remaining on the surface being wiped off and the job left overnight. Proceed the next day with a coat of oil primer followed by the usual oil filler.

It will be found that wood treated in this manner is more likely to be satisfactory when cellulose is applied. Still further, in the case of wood, it should be known that it is necessary for wood to breathe, so for this purpose, if it is possible, do not paint the back.

Repairing Polychromatic Lacquer Finish

A method of finishing which is becoming more popular is that of the polychromatic lacquers, sometimes known as scintillating or opalescent. The scintillating effect which these lacquers give is obtained by the addition of metal powders to the lacquer. From the paint-shop angle these finishes have several snags when they come in for repairs, the principal one being that they are very prone to appear patchy or shady. This is due to the fact that in the polishing operation, heat is generated, which tends to tarnish or blacken the fine metal particles. If it were possible to use the same amount of pressure all over the job, which of course it is not, then it would not matter. So, to overcome this trouble, some mass-production manufacturers apply coats of clear lacquer over this finish. This lacquer is polished, thus obviating the trouble. But the use of clear lacquer is not to be recommended, because the durability of this material is not as good as the pigmented type.

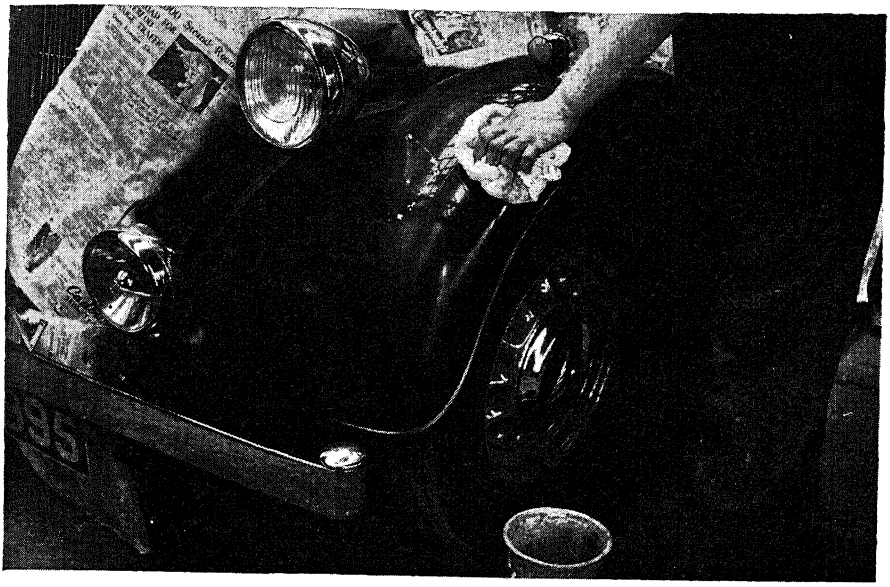


Fig. 7.—PUTTING A FINISH ON A CELLULOSED WING
An abrasive compound is first used and a high gloss is then obtained with a finishing polish. (*By courtesy of the Provincial Sheet Metal Works, Cheam*)

Avoiding Patchy Effect

The best method is as follows: After the last coat of polychromatic lacquer has been applied, overspray with two further finishing coats, which should be nearly all thinners, to which is added a small percentage, say 20 per cent., of the polychromatic lacquer. It will be found that if the job is done in this manner it can be polished in the ordinary way without the "shady" effect being noticeable.

Matching

A still further trouble with this particular finish is that of matching. Polychromatic finishes fade rather more than straight-pigmented lacquers, and it is for this reason, coupled with the fact that the metal powder in the lacquer tarnishes, that in many cases it is almost impossible to get a dead match in the case of spotting in or repair work.

Renovating Fabric Bodies with Cellulose

Although fabric-covered bodies are almost a thing of the past, at the same time it is necessary that every operator should know the correct way to renovate this material with cellulose. It is not all types of fabric

that are suitable for cellulose, for example those made on a rubber base. Test by spraying a small portion (in an out-of-the-way place) and examine when dry. If the surface is free from shrivelling and cracking it will be safe to go ahead with the job.

In the first place, specially prepared enamels are needed. They yield a flexible film with a suitable degree of gloss straight from the gun, as it is impracticable to polish cellulose enamel in the usual way when applied to fabric.

To prepare the surface of the fabric, it should be washed with petrol or turpentine to remove all trace of polishes, grease, etc. The use of a small nail-brush will materially assist in freeing the grain of the leather from same.

Two coats of fabric enamel are usually sufficient. The first of these must be a light coat, followed 30 minutes later by one full coat.

Colour Mixing

Perhaps one of the most important things in the paint shop to-day is that of colour mixing. This is due to the enormous amount of repair work which requires matching up to the existing colour. Colour matching is a scientific art, and can be brought to perfection only by years of practice and experience. So it is essential that every operator should endeavour to learn something of this art. A natural eye for colour is perhaps the greatest asset of all. Then come the fundamental principles.

Actually there are only three colours, these being red, blue, and yellow, and are known as the primary colours. Black and white are not known as colours but as neutral tints. They are, however, indispensable for mixing and tinting. If any two of the primary colours are mixed together, they will produce another colour ; this is known as a secondary colour; and to take the matter one step farther, if any two of the secondary colours are mixed together, these will produce yet another colour, which is known as a tertiary colour. With this range of colours, known as base colours, it is possible, by varying the quantity, to produce every shade, hue, and tint in the vast range of nature. These base colours are those which should be used for matching, as they will give greater permanency than colours which are obtained by intermixing ordinary standard colour-book shades, because when standard colours are intermixed by what can be termed a " hit-and-miss " method, the result may be that of considerable fading, due to the fact that standard colours have already been made up from the base colours. The proportions, therefore, are unknown to the mixer.

A good range of base colours is as follows :

Prussian Blue
Ultramarine Blue
Dark Chrome Green

Light Chrome Green
Orange Chrome
Lemon Chrome
Ochre
Burnt Sienna
Red Oxide
Crimson Red
Maroon
Deep Red
and
Black and white.

It must always be remembered that colour in its wet form is slightly different from when it is dry. There is no hard and fast rule which can be followed, because some pigments dry lighter and some darker; and furthermore, a matt film of colour will also show a slight difference from one which has been polished. So after a match has been made. it will not show true to colour until the film of cellulose has dried out and been polished. Therefore a slight allowance must be made for this change.



Fig. 8.—THE TRIMMING HAS TO BE PROTECTED FROM THE CELLULOSE SPRAY DUST

Here is an example of how the trimming is masked whilst panels and doors are being cellulosed.
(*By courtesy of the Provincial Sheet Metal Works, Cheam*)

As a guide to mixing any particular shade, the following is a broad outline. Consider the colour to be matched and select the nearest shade obtainable, rather lighter than darker. Next consider the top tone of the shade in question. For example, a green may have a blue tone predominating; or alternatively a yellow cast. It will then be necessary to decide whether that top tone can be introduced to the enamel you have selected, to act as a base colour, by intermixing perhaps another tone which embodies the "tone" necessary.

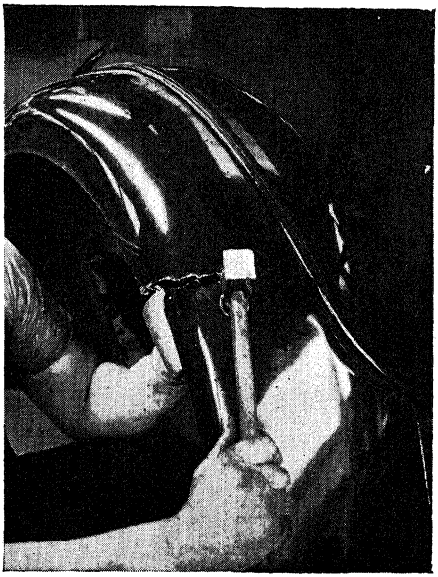


Fig. 9.—REPLANISHING REAR WING IN POSITION PRIOR TO WELDING

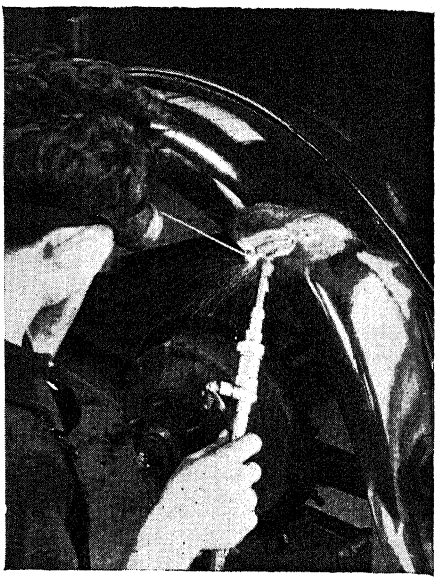


Fig. 10.—WELDING FRACTURE IN REAR WING BY OXY-ACETYLENE PROCESS
(*By courtesy of the Provincial Sheet Metal Works, Cheam*)

Some Standard Colours

A number of colours and the method by which they can be produced from the base colours are given below. They are very familiar to the paint shop, as they are the standard colours used by many mass production car manufacturers. It must be made quite clear that if these colours are made to the following formulas, they will not be a dead match to the cars in question. Firstly, because the existing colour has weathered, which naturally alters it, sometimes quite considerably. Reds in particular are prone to this. Secondly, the base colours may vary according to the method of manufacture. For instance, manufacturer "A's" Prussian Blue may not be identical in shade to manufacturer "B's," etc. It must be left to the intelligence of the mixer, coupled with the information which follows, to make a successful match.

Austin Westminster Green

Dark Chrome Green	67 parts
Burnt Sienna	8 ,,
Black	25 ,,

Hillman Aero Blue

White	67 parts
Black	18 ,,
Ochre	8 ,,
Prussian Blue	7 ,,

Morris Green	
Prussian Blue	52 parts
Lemon Chrome	26 ,,
Black	10 ,,
Orange Chrome	6 ,,
White	6 ,,
Rover Grey	
White	83 parts
Black	13 ,,
Lemon Chrome	4 ,,
Standard Fawn	
White	83 parts
Burnt Sienna	9 ,,
Black	8 ,,
Light Chrome Green	Tint only
Ford Vineyard Green	
Light Chrome Green	50 parts
Black	34 ,,
Prussian Blue	16 ,,
Orange Chrome	Tint only

Refinishing Dashboards and Fillets

The paint shop is often called upon to refinish dashboards and fillets which are, in common with modern practice, made of metal, whereas the finish must represent that of wood. Many of these finishes are obtained by the use of photographic transfers. These transfers are applied in the usual manner and finished with clear lacquer.

The operator can produce this finish in the following manner, bearing in mind that the success of this depends entirely on his skill as a grainer : spray one or two coats of cellulose enamel of a colour which most closely resembles the lighter colour of the desired wood to be copied. When dry, brush over this one coat of water-colour which, in this case, should match the darker shade of the grain. Before this is dry it should be grained in the usual manner of graining. When dry, one or more coats of cellulose clear lacquer should be applied. In explanation : graining is carried out in water-colour because it could not be done satisfactorily in cellulose, and were an oil-colour used, this would give rise to trouble when the clear lacquer is applied in finishing.

Sign-writing in Cellulose

Sign-writing on commercial vehicles which are to be finished in cellulose is sometimes a problem. The following method for cellulose lettering by spray is unequalled when cost is not the most important feature. Prepare the surface in the usual way up to the filler stage. Now spray, on

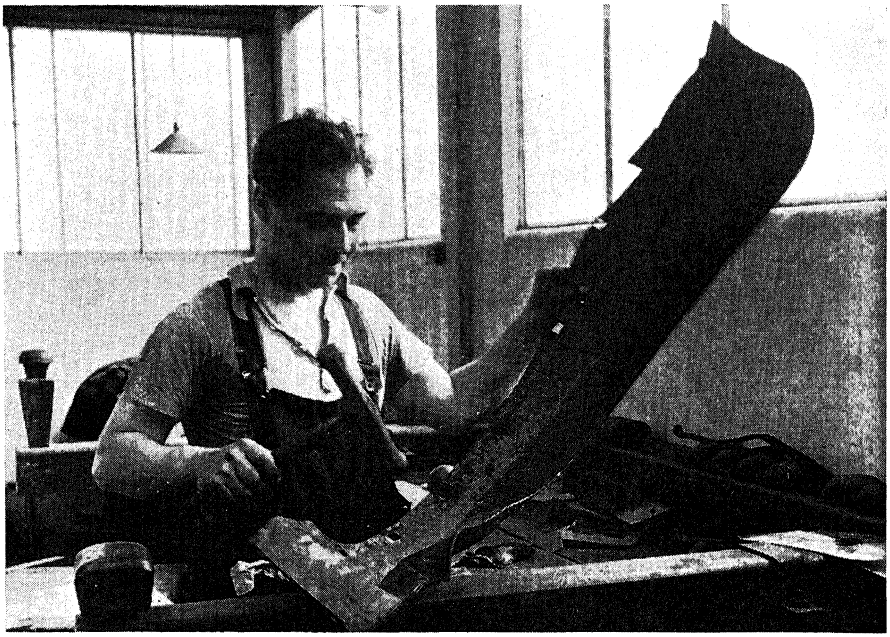


Fig. 11.—WHEN A WING IS TOO BADLY DAMAGED TO BE REPAIRED ON THE CAR, IT IS REMOVED AND REPAIRED AT THE PANEL-BEATER'S BENCH (*Provincial Sheet Metal Works*)

the area to be occupied by lettering, three coats of cellulose enamel of the shade required for the letters themselves. The sign-writer now writes in the lettering with masking compound. After the writing is completed, overspray the whole surface with three coats of the colour desired for the background. When the last coat is dry, wash the surface with water to remove all traces of the masking compound, thus displaying the writing underneath. This finish, unlike ordinary sign-writing which has been written in oil-colours, can be polished with the rest of the body without fear of its rubbing off. Furthermore it has the look of an enamelled sign.

COMMON TROUBLES, CAUSES AND REMEDIES

Here follow a few of the most common troubles, giving their cause and remedy.

Orange Peel

Surface resembles slightly pebbly effect.

Cause: Too high or too low air pressure. Spraying consistency incorrect.

Remedy: Check air pressure. This should be, as previously remarked in this article, approximately 55 lb. A test for the spraying consistency

H.H. LIBRARY

can be carried out as follows: thin the material approximately 50–50 with thinners and spray one stroke across a test panel. On examination should it be found that either edge has a speckly appearance, it is probable that the material is not quite thin enough, because the outer edges should fade away evenly to nothing.

Blushing

This is a white haze over all or a portion of the surface.

Cause. Unsuitable thinner or lacquer sprayed under bad conditions, such as cold, draughts, or humid atmosphere.

Remedy. Do not try to polish out this haze, but overspray with a non-blushing thinner.

Pin-holding or Bubbling

Cause:

(*a*) Use of too rapid-drying thinner.
(*b*) Too rapid surface drying.
(*c*) Air pockets trapped under surface.
(*d*) Moisture coming through air line.

Remedy. Use slower-drying thinner. Avoid draughts. Blow out air line and inspect pressure tank for traces of water.

Bleeding

Bleeding occurs when a pale shade is sprayed over such colours as reds and dye blacks.

Cause. Through the use of various dyes in these colours.

Remedy. To refinish over a bleeding surface spray two coats of lacquer sealer to which has been added aluminium powder in the proportion of ½ lb. powder to 1 gal. sealer. Allow to harden off 2 or 3 hours before applying the new colour.

Body Solder

This is used for the purpose of filling up bad imperfections and frequently gives rise to trouble.

Cause. Principally due to the flux used for tinning the panel, the result usually being that all the cellulose applied over this solder will frequently be found to crack and flake off.

Remedy. Make sure that a suitable flux is used and thoroughly scour the repair with a coarse grade of water-paper before any material is applied.

Polishing

Although polishing is usually carried out by hand, the mechanical rotary polishing machine is favoured by some. It requires experience to use such a machine, and extreme care must be taken, otherwise the

lacquer film can very easily be burnt, due to the heat which is generated by the polishing mop revolving at high speed. The tensile strength of the cellulose film will suffer; and furthermore, an excess of colour may be removed, leaving the surface shady. A special smoothing compound is necessary, and it should be applied to the part which is being polished and not directly to the polishing mop.

Masking

For protecting glass and plated parts which are not to be coated, and for duotone work, it is necessary to mask off the various parts. For this purpose, the masking can be carried out by the use of either masking paper, adhesive masking tape or masking compound. Masking paper is adhesive on one side, and can be purchased in various widths. It is applied by moistening with water and sticking in position. It should be stripped off when possible whilst the last coat of cellulose enamel is still wet, to ensure clean dividing lines without tearing the film. Masking tape is self-adhesive and can be used repeatedly. Masking compound is in liquid form. It should be brushed freely over the surface to be masked but not flooded. An important point to remember when using this material is that it must be sealed by applying a thin coat of enamel at a reduced air pressure. The reason for this is that if a full coat were applied at the usual air pressure, it would most probably penetrate the masking compound and so prevent its easy removal. It will be found that if the compound is used correctly, it can easily be removed after the enamel coats are dry by sponging with clear water.

In conclusion, it is hoped that this short article will prove of assistance to those employed in the cellulose refinishing business.

LUVAX BIJUR CHASSIS LUBRICATION

By DOUGLAS PERCIVAL

THERE is now an increasing demand from the motoring public for automatic chassis lubrication, this being no doubt largely due to the trend of modern coachwork design, which tends to make the various lubrication points more and more inaccessible. As a result, a greater number of car manufacturers are now including an automatic system in the standard equipment of their various models, and it is a method which, without doubt, will become more generally adopted as time goes on.

The function of a chassis lubrication system is to supply a measured quantity of oil to the various chassis bearings in accordance with their respective requirements. The bearings lubricated are usually front-axle

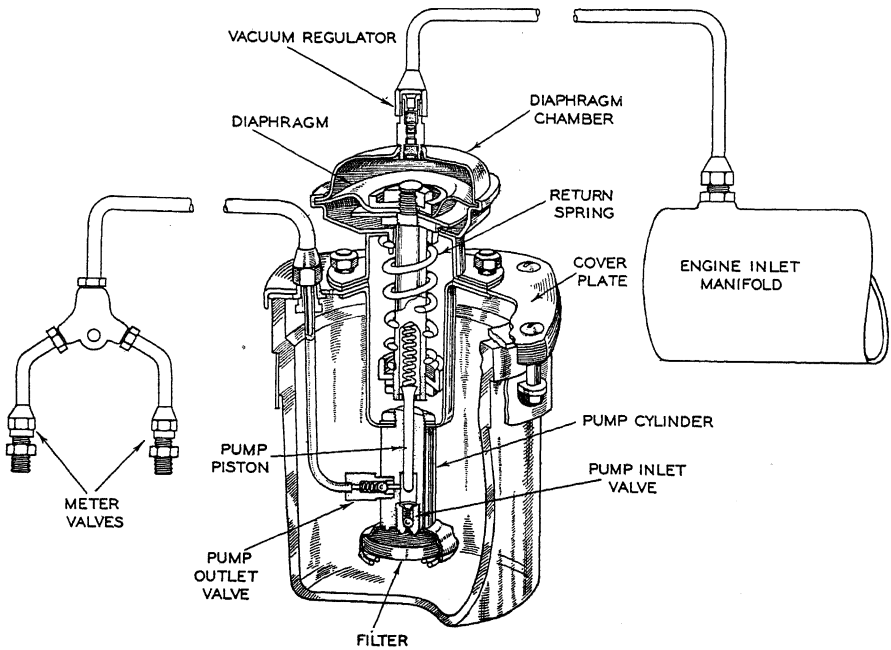


Fig. 1.—PUMP UNIT AND OIL RESERVOIR OF LUVAX BIJUR VACUUM-OPERATED CHASSIS LUBRICATION SYSTEM

swivel pins, steering-ball pins, spring shackles, and brake shafts, etc., in fact, all bearings requiring lubrication with the exception of those that rotate, such as the wheel hubs and universal joint.

Three Types

The Luvax Bijur system is made in three types, namely :

(1) The vacuum-operated automatic system.
(2) The thermal automatic system.
(3) The manually operated system.

Each of these systems comprises an oil reservoir, a pumping unit, and a system of piping to distribute oil to the various bearings, where meter valves are located, which control the amount of oil passed, so that each bearing receives the correct quantity of lubricant.

THE VACUUM-OPERATED SYSTEM

We will deal first with the vacuum-operated system. The pump unit is mounted inside the oil reservoir, these two parts forming a complete self-contained unit, as shown in Fig. 1. It is usually mounted on the engine side of the dash. On top of the pump unit is a diaphragm chamber in which is located a diaphragm, to which is attached the pump plunger. A spring is incorporated which exerts a downward pressure on the diaphragm and plunger. Screwed into the top of the diaphragm chamber is a vacuum regulator valve, and from this is taken a pipe to the engine intake manifold. The operation is as follows :

Operation of the Vacuum-operated System

When the engine is started up and running at idling speed, the vacuum in the inlet manifold is of a high order, and consequently the pump diaphragm is drawn up towards the top of its stroke. When the engine is accelerated, the vacuum decreases, and the spring in the pump unit returns the diaphragm towards the bottom of its stroke. When the engine is running at medium speed, the vacuum is of a sufficient value to hold the diaphragm midway between the top and bottom of its stroke. Movement of the throttle causes a variation of vacuum in the inlet manifold, and this in turn causes an upward or downward movement of the diaphragm, which being connected directly to the pump piston causes pumping.

In ordinary road driving, there occurs an almost continuous change of vacuum in the engine intake manifold, due to throttle changes. Actually, it is like a wave, having its peaks and hollows a little above and a little below an average value. These waves occur rather slowly and the diaphragm ordinarily follows them closely. However, in conditions of heavy traffic, when there are more violent accelerations and decelerations, the changes of manifold vacuum occur more frequently and are of greater magnitude. In order to limit their action on the diaphragm and reduce

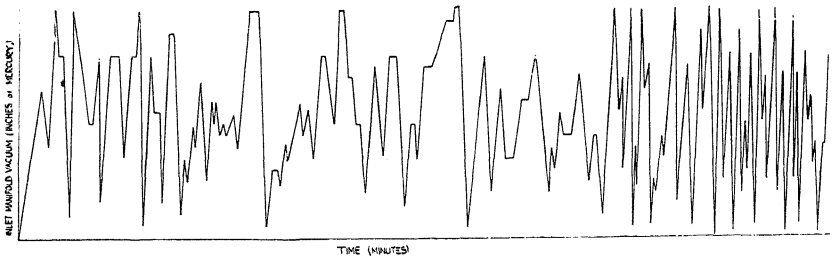


Fig. 2.—DIAGRAM SHOWING VACUUM CHANGES IN INLET MANIFOLD

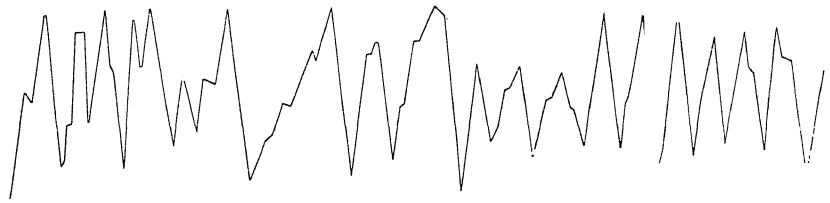


Fig. 3.—DIAGRAM SHOWING CORRESPONDING VACUUM CHANGES IN PUMP DIAPHRAGM CHAMBER WITH RATE TR2 VACUUM REGULATOR

their effect to approximately the same as that obtained under average road conditions, the vacuum regulator is fitted between the diaphragm chamber and the manifold.

The Vacuum Regulator

In the vacuum regulator is a small accurately sized restriction orifice, the area of which is arranged to permit a comparatively slow flow of air—thus frequent large-magnitude vacuum fluctuations in the manifold do not have a full effect on the pump diaphragm. This is illustrated clearly in Figs. 2 and 3. Fig. 2 is a diagram of the vacuum fluctuations in the manifold of a typical six-cylinder car whilst being driven along a road on the outskirts of a town, and the effect of driving through a section of heavy traffic which was met with is seen at the right-hand end of the diagram. Fig. 3 shows the vacuum variation in the pump diaphragm chamber and clearly illustrates the effect of the vacuum regulator. It will be observed that the " peaks " and " hollows " due to the traffic section in Fig. 2 have been damped out—the results being that the pump output is consistent within reasonable limits during both open-road and traffic conditions.

From the foregoing it will be seen that the vacuum regulator is a very

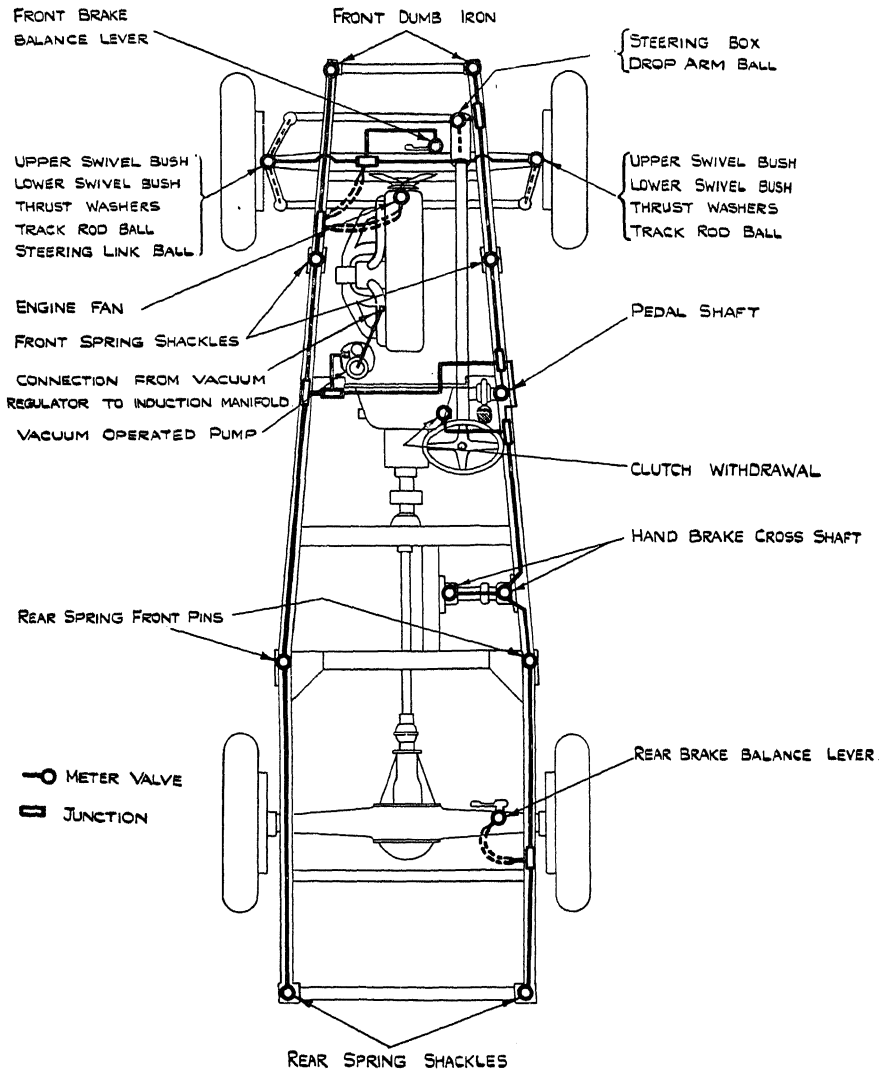


Fig. 4.—DIAGRAM OF TYPICAL LAYOUT OF VACUUM-OPERATED LUVAX BIJUR CHASSIS LUBRICATION SYSTEM

This shows the pump and reservoir unit mounted on the engine side of the dashboard, and a flexible connection between the vacuum regulator and the engine inlet manifold—usually termed the " vacuum " connection. A small brass or copper pipe is used for the oil pipe line, and is shown running from the pump outlet to a junction on the dash and from thence to the offside and the nearside of the chassis.

important part of the pump unit, and a moment's thought will show that the size of its restriction orifice controls the pump output. The vacuum regulators are therefore made in different sizes or " rates," so that the pump output may be arranged to suit the requirements of the car to which it is to be fitted. The " rate " number is stamped on each regulator, and it is important, when fitting a replacement, to ensure the same " rate " being used as that originally fitted.

Further remarks concerning the vacuum regulator are included under " maintenance "—and these should be noted carefully.

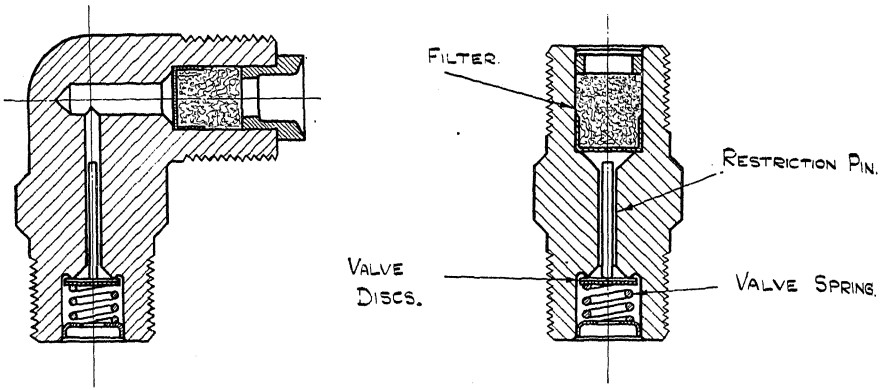
The Meter Valves

The oil is delivered from the pump outlet, through a system of piping to meter valves located at each chassis bearing. In each meter valve is an accurate restriction orifice, which controls the flow of oil to the bearing, and also a valve which prevents oil draining away from the system whilst the car is at rest. The meter valves are made with restriction orifice areas, of different sizes, so that various rates of flow are obtained and thus the requirements of both large and small bearings may be catered for satisfactorily irrespective of the fit of the shaft in the bush. Each meter valve is stamped with its rate number.

A Typical Layout of Vacuum-operated System

A diagram of a typical layout is shown in Fig. 4. This shows the pump and reservoir unit mounted on the engine side of the dashboard, and a flexible connection between the vacuum regulator and the engine inlet manifold ; this is usually termed the " vacuum " connection. For the oil pipe line a small brass or copper pipe is used and is shown running from the pump outlet to a junction on the dash and from thence to the offside and the nearside of the chassis, branching on each side to the front and rear dumb irons. The meter valves at the various bearings are connected directly to the main pipe line by " T " heads or by branch lines, such as shown for the clutch-withdrawal bearing. Flexible connections are used between the frame and the axles.

Briefly, then, the operation of the system is as follows : whilst the car is running, the pump delivers a slow, continuous feed of oil through the pipe line to the meter valves situated at the various bearings. The vacuum regulator controls the amount of oil delivered by the pump, and the volume delivered is proportioned out to the various bearings in the correct ratio by the meter valves. A low-rate meter valve at, say, the brake cross-shaft ensures that only the small amount of lubricant necessary is delivered, whilst a higher-rated meter valve at, say, the front-axle king pin, ensures an adequate supply. The complete system is always solidly full of oil, so that immediately the pump starts working, delivery commences through the bearings.



Elbow type meter valve Straight type meter valve

Fig. 5.—CONSTRUCTION OF METER VALVES

Construction of the Vacuum-operated System

The combined reservoir and pump unit used with the vacuum-operated system is of a simple construction. The reservoir, which is carried in a steel mounting bracket, is made of glass, so that the oil level may readily be seen. The cover plate is held in position by four bolts attached to lugs on the mounting bracket. A cork gasket is used to make a joint between the glass and the metal cover plate.

The Pump Unit

The pump unit, which is carried on the cover plate, comprises a long piston of small diameter, which affords a tight oil seal without packing. The pump is provided with self-contained inlet and outlet valves, in each of which a ball is pressed against a conical seat by a small spring. From the outlet valve, at the side of the pump cylinder, a pipe leads to the outlet connection mounted on the cover plate. Oil is admitted to the inlet valve in the bottom of the pump cylinder through a removable felt filter, backed by a fine-mesh brass gauze.

The pump cylinder is bolted to a "U" strap, depending from the cover plate, and these parts are permanently secured together, forming a sub-assembly.

The pump piston and its actuating diaphragm, together with the diaphragm chamber, constitute a sub-assembly also. The upper end of the piston is provided with a universal joint to connect it to the diaphragm shaft, which in turn is bolted to the underside of the diaphragm. The latter is urged downward against a limiting stop by a large-diameter coil spring. The outer periphery of the diaphragm is secured between the upper and lower halves of the diaphragm chamber. As already mentioned, in the upper half of the latter is screwed the vacuum regulator, which is connected by a length of pipe to the engine inlet manifold.

The vacuum regulator comprises a body screwed at each end, two felt and brass gauze filters, a baffle disc, a dust-trap cup, and a restriction cup, the whole forming a self-contained unit.

The Oil Pipe Line

Soft brass or copper tubing of $\frac{5}{32}$-in. outside diameter is used for the oil pipe line, and $\frac{3}{16}$-in. outside diameter is used for the vacuum line. All connections are made with screwed joints, no soldering being used anywhere in the system.

The connection of the pipe line to the junction-pieces and meter valves is made with compression sleeves (or olives), which are permanently pinched on to the end of the tube as the nut is tightened up.

The construction of the meter valves is shown in Fig. 5. Each meter valve comprises a body threaded externally at each end and drilled in the centre with an accurately sized restriction hole. In the body is fitted, first, a felt and gauze filter to protect the restriction orifice from any dirt, chips, or copper oxide as might originally be in the pipe line; secondly, an accurately sized restriction pin, positioned in the restriction hole, so that the clearance between the two forms an accurately sized aperature. In all the meter valves, the hole in the body is the same size, but the restriction pins are of different diameters, thus affording different restrictions and consequently different rates of flow. Finally, comes a valve, which in some types consists of a floating disc and in others of a lightly spring-loaded disc. The purpose of the valve is to prevent oil draining away when the system is not working.

MAINTENANCE AND SERVICE REPAIRS OF VACUUM-OPERATION SYSTEM MAINTENANCE

The normal maintenance required is as follows:

(1) Inspect the oil level in the reservoir and replenish if necessary with Luvax Chassis Oil or an alternative approved by the manufacturer of the car to which the system is fitted. The choice of oil is important; it must be of the correct viscosity, anti-corrosive, and free from gumming tendency, therefore do not use any other than Luvax Bijur Chassis Oil or an approved alternative. A filler cap is provided on the coverplate. The reservoir holds approximately $1\frac{1}{3}$ pints. The oil level should not be allowed to fall lower than $\frac{3}{4}$ in. from the bottom. When replenishing, do not fill above the upper edge of the mounting bracket. The oil consumption, of course, depends upon the number of bearings being lubricated. A system comprising sixteen meter valves, uses approximately 1 pint of oil per 1,500 to 2,000 miles.

(2) The vacuum regulator should be replaced by a new one every 10,000 miles. This is because dirt and dust, which are drawn in with the air, tend to choke the filter elements, causing the action of the pump to be restricted. Replacement vacuum regulators are obtainable from the

makers. Make sure that the replacement is of the same "rate" as the original one. The "rate number" is stamped on each and should be quoted when ordering. When fitting the new one, it is advisable to first screw the regulator in until one complete thread is holding; then add a drop of white-lead paint, hermetite, or some such jointing material to the remaining threads before screwing the regulator completely home. This will prevent air leak at the thread.

(3) An occasional glance should be given to such remote points as the front and rear dumb irons, or the steering-ball pins. If the system is working correctly, oil will be visible at these points—a slight wetness should be seen. If they appear dry, the system should be examined. Instructions for this are given below under "Service Repairs."

"Service Repairs" (for the vacuum system)—All Chassis Bearings Dry

Let us first of all assume that the system on a car is being examined and it is found that all the bearings are dry. This may be due to the pump unit not working or to an uncoupled or faulty pipe connection, or broken pipe which allows the oil delivered by the pump to take the path of least resistance and to fall on to the ground, i.e. to pass out of the open-minded pipe.

The latter possibility may be readily checked by a visual inspection of the pipe line. A leakage is very noticeable; it is well known that a little oil makes a lot of "mess." The remedy is to repair the leakage and prime the system.

After any failure or repair involving a leakage from the pipe line, the system should be primed, as for efficient working it must be solidly full of air-free oil. The pipe line should be disconnected at the pump outlet and the priming gun attached to the end of the pipe. Force oil through until air-free oil is reaching each bearing. The makers supply a "priming gun" complete with a convenient flexible connection for this purpose. On some cars a priming nipple is incorporated in the junction on the engine side of the dashboard. This provides a convenient point for attaching the priming gun, and avoids having to disconnect the pipe at the pump outlet. If no priming gun is available, the system may be primed by operating the pump unit by hand. To do this, first remove the two nuts and lock washers at the base of the diaphragm chamber. The pump can then be operated by alternately raising and lowering the diaphragm unit about $\frac{3}{4}$ in.—this will force oil out of the pump outlet into the pipe line. This method is slower than using a separate priming gun, but can be carried out effectively in approximately 15 minutes. The outflow from the pump is very small, as the flow required to correctly lubricate sixteen points on a chassis is only 1 cu. in. per 100 miles.

Checking the Pump Unit

To check the pump unit and locate trouble, if any, proceed as follows: first of all, make sure that the vacuum regulator is functioning correctly.

See that the diaphragm and pump piston respond to vacuum fluctuations. To do this, start the engine and disconnect the vacuum line at the vacuum regulator. By holding the vacuum tube tightly against the vacuum regulator, the piston should be drawn up to the top of its stroke. By removing the vacuum tube from the regulator, the piston should return to the bottom of its stroke in 5 seconds or less. If the piston does not move as described, the vacuum regulator should be replaced by a new one of the same " rate." If fitting a new regulator does not have the desired effect, it indicates either a faulty diaphragm or piston, and a replacement " diaphragm and piston assembly complete " should be obtained from the makers.

If, however, the vacuum regulator and diaphragm are found to be correct, the next step is to see that movement of the pump piston causes delivery of oil. This is easily checked, by disconnecting the chassis oil line at the pump outlet and removing the two nuts and lock washers at the base of the diaphragm chamber. Then operate the pump by alternately raising and lowering the diaphragm unit about $\frac{3}{4}$ in. On the down strokes, one or two drops of clear oil, free from air, should be discharged at the outlet. During the upward movement, oil should not be sucked back down the outlet hole. Also, when a finger is held over the oil-outlet hole, there should be a distinct sign of pressure during the down stroke.

Clogged Filter

If the above test reveals faulty operation, it may be caused by the filter having become clogged up, due to the use of unsuitable or dirty oil. To examine the filter, remove the four screws, holding the cover plate and pump assembly to the mounting bracket ; the complete assembly can then be withdrawn. If the filter is found to be dirty, it can be readily taken out by removing the spring-retaining ring. It can then be washed in paraffin or petrol, until clean and white. Should the results still be unsatisfactory, the complete unit should be returned to the makers for repair or replacement, as special tools and fixtures are required for a complete dismantle and reassembly.

Fitting New Glass Reservoir

To fit a new glass reservoir, should the original one have been broken, disconnect the vacuum line and the oil line at the pump outlet. Then remove the four screws holding the cover plate to the mounting bracket. The cover plate may then be lifted off and a new reservoir dropped into place in the mounting bracket. The bottom of the reservoir is flat, so that it will stand upright when dismounted from the car.

Two further points in connection with the pump unit should be noted. Special care should be taken when reassembling the diaphragm and pump assembly to make sure that the piston enters the cylinder correctly and there is no excessive friction, caused by dirt or burrs. Secondly, the round

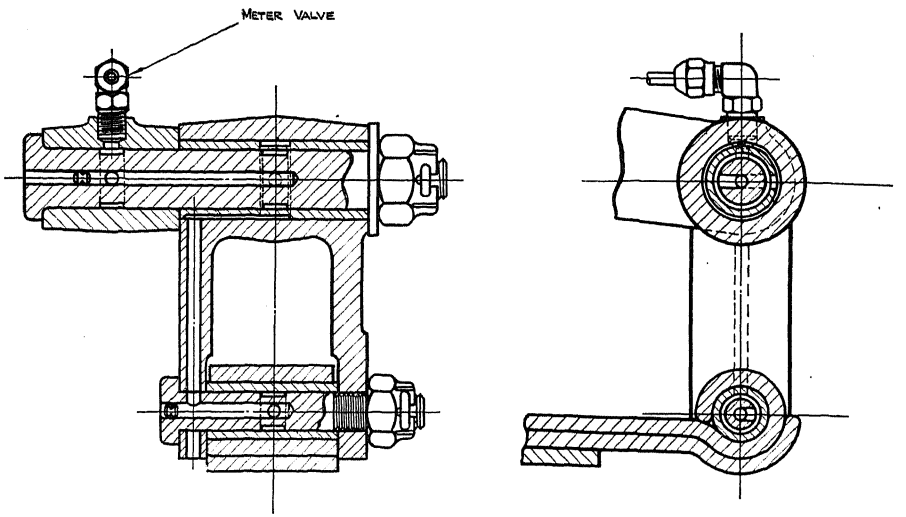


Fig. 6.—TYPICAL REAR-SPRING SHACKLE
Showing method of lubrication.

nut on the pump shaft is set at the factory to give the correct loading on the spring, and is secured in place by staking the pump shaft, through a hole in the nut. If the pump has been tampered with and the nut turned, the entire assembly should be returned to the makers for resetting, as to get the best results it is necessary for this to be done with a specified vacuum in the diaphragm chamber.

Finally, should the above tests show the pump unit to be working correctly and yet when connected up and the car engine is accelerated and decelerated no oil is delivered, then the vacuum line and connections should be examined. It is imperative that these are airtight.

All Bearings Insufficiently or Excessively Lubricated

We have now considered the correct action in dealing with a car on which all the chassis bearings are dry. Let us now take a car on which all the bearings are receiving oil but the supply is insufficient, or alternatively, all the bearings are receiving an excessive supply.

In both of these instances, the output of the pump would appear to be unsuitable, being too low in the former case and too high in the latter. The pump output may be varied by fitting a higher- or lower-rated vacuum regulator as required. They are made in four rates, i.e. TR1, TR1½, TR2, and TR3. However, before changing the rate of the vacuum regulator, careful inquiry should be made to ascertain if the insufficient or excessive supply, as the case may be, has been occasioned during normal usage. For instance, the appearance of an insufficient supply may be due

to the car having been run with the reservoir empty, prior to the inspection ; or again—is the excessive wetness due to the system having been hand-primed a week or so previously ?

A Number of Dry Bearings (fed by different Meter Valves)

If a portion of the system is found to be dry it is probably caused by a stoppage in the pipe line which feeds that portion. As an example, let us assume that the system shown in the diagram (Fig. 4) has the following dry bearings on the offside : Hand-brake cross-shaft, rear-spring anchor pins, rear brake balance-lever, and rear-spring shackle. A study of the diagram will show that a stoppage has occurred in the length of pipe between the junction which connects to the clutch withdrawal, and the hand-brake cross-shaft, oil having reached the former but not the latter. The length of pipe between these two points should be removed and cleaned or a new piece of pipe fitted and the system primed. A stoppage in the pipe line rarely occurs, but when it does it is more often due to the pipe having been flattened by a blow or a pinch than to foreign matter in the pipe.

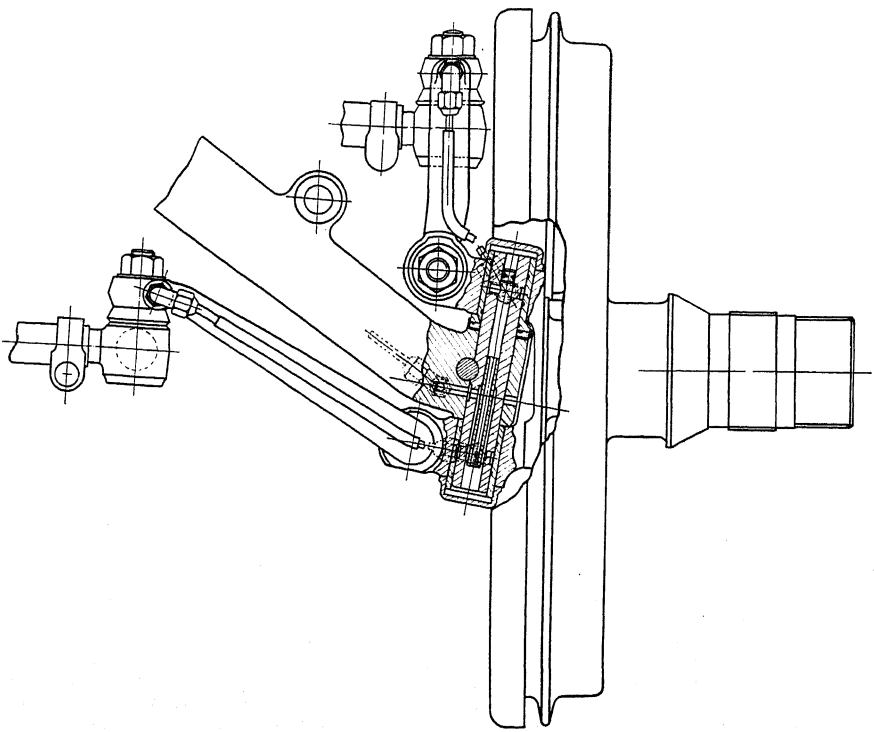


Fig. 7.—TYPICAL FRONT-AXLE INSTALLATION WITH LUVAX BIJUR LUBRICATION

One Bearing receiving an Excess of Oil (or a Group of Bearings fed from One Meter Valve)

If only one bearing is found to be receiving an excess, or a group of bearings fed from one meter valve, the latter should be changed. The feed to the bearing may be varied by fitting a higher- or lower-rated meter valve as required; they are made in eight different rates, i.e. 00, 0, 1, 2, 3, 4, 5, and 6. In a case such as this, however, it is advisable to first fit a new valve of the same rate number, as the original one may have been incorrectly calibrated. The excess oil should then be wiped from the bearing and the performance watched for the next hundred miles or so. If the supply is still excessive a lower-rated one may be fitted.

Only One Dry Bearing (or a Group of Bearings fed from One Meter Valve)

Should it be found that only one bearing is dry, or a group of bearings fed from one meter valve, it indicates either a fault in the meter valve, or (if the meter valve is situated at a terminal point of the system, such as the rear shackles or brake cross-shaft, as in Fig. 4) a stoppage in the pipe line.

A check should be made by disconnecting the pipe line at the point where it is connected to the meter valve. If oil is not present in the end of the pipe, trace the pipe along to the next connection, and disconnect and examine; repeat this until the stoppage is traced. A flattened pipe, caused by a blow or pinch, may be the source of trouble, in which case a new length of pipe should be fitted and the system primed.

If it is found that oil has reached the end of the pipe, adjacent to the meter valve, the latter should be unscrewed from the bearing and examined. If the outlet end of the meter valve is dry, it indicates a stoppage, and a new valve of the same rate should be fitted.

When fitting a new meter valve, either at the end of a line, or a T-head —inserted in the line—care must be taken to assemble the filter end of the meter valve towards the pump, so that the flow of oil has to pass through the filter before reaching the restriction orifice. The filter end of the meter valve can be distinguished as the felt is discernible through the end of the body.

Instances may be met with where oil is found to be emerging from the outlet end of a meter valve and yet it does not reach the actual bearing surface; this may be due to the internal oil ways in the bearing parts having been incorrectly drilled, left undrilled, or choked up. The effect of either of these faults will be readily appreciated by a study of Fig. 6 and Fig. 7.

Lubrication of Typical Rear-spring Shackle

Fig. 6 shows a typical rear-spring shackle. It will be seen that the meter valve is screwed into a hole in the bracket which communicates with an annular groove around the pin. The oil passes around this groove and

through a radial hole in the pin to a longitudinal hole in the centre, through which it passes to the upper bearing. Part of the oil spreads along the bearing surface and part passes out through a radial hole in the bush to grooves formed in the outside of the bush. These grooves communicate with a hole drilled in the shackle link, down which the oil flows to the lower pin in which holes and a groove are formed, to pass it to the surface of the lower bearing.

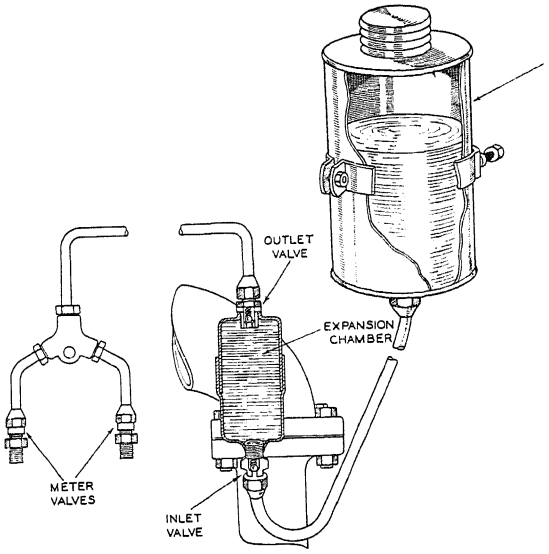


Fig. 8.—THE LUVAX BIJUR THERMAL SYSTEM

It will be obvious that if either of the oil holes or grooves are choked up or left undrilled, or if the parts are incorrectly assembled so that the holes and grooves do not connect up, oil will not reach the bearing surfaces as intended, although it may be reaching the outlet end of the meter valve.

Typical Front-axle Installation

Fig. 7 shows a typical front-axle installation. With this arrangement the oil is carried from the frame via a flexible connection to the axle beam. A pipe is run along to each end of the beam, where a meter valve is positioned. The meter valve discharges the oil through a hole in the end of the beam and the king-pin to the centre of the pin. In the centre of the pin a standpipe is fitted. The oil rises up the annulus around the outside of the standpipe, and part flows through a radial hole in the pin to lubricate the upper bush. A hole is also provided which communicates with a pipe running down the steering arm to the ball pin. It will be noted that a slot is formed in the upper end of the standpipe ; this is to ensure that the correct proportion of oil flows down the centre of the standpipe to the lower end of the king-pin, whence it is carried via suitable oilways to lubricate the thrust, bearing, lower bush, and track-rod ball. In this instance one meter valve feeds a number of bearings, and it will be apparent that if the oil ways are not correct the oil will not reach the desired places.

The shackle and axle arrangements shown in Figs. 6 and 7 are typical

examples only. Actually there are many variations, according to the design requirements of the various cars.

THE LUVAX BIJUR THERMAL SYSTEM

Description

This system is illustrated in Fig. 8. The pumping action is caused by heat from the engine. The system comprises an oil reservoir, usually mounted on the engine side of the dashboard, which supplies oil to an expansion chamber, in the form of a closed cylinder, with inlet and outlet valves, mounted adjacent to the exhaust manifold. Oil is fed from the expansion chamber to distributing pipes and meter valves identical to those used with the Luvax Bijur Vacuum System—already described.

Operation of the Thermal System

When the system is initially fitted, it is primed and the reservoir filled so that all pipes and the expansion chamber are solidly full of oil.

When the engine is started, the oil in the expansion chamber heats up and expands (due to the expansion chamber being in close contact with the exhaust manifold) and oil is forced through the outlet valve to the distributing lines and meter valves. When the temperature drops, the oil in the expansion chamber contracts and a replenishment charge is automatically drawn through the inlet valve from the reservoir. This cycle occurs with every rise and fall of temperature in the expansion chamber.

Changes in engine temperature, and therefore of the temperature in the expansion chamber, due to variation in running conditions, such as between flat roads and hill climbing, or slow and high speeds, will produce a delivery of oil. Most of the flow, however, takes place with the initial temperature rise at starting. The starting temperature under the bonnet, of course, varies approximately as the outside temperature, but the running temperature varies only a little. Therefore, the oil delivery will be slightly less in hot weather when the starting temperature is high, than in cold weather when the starting temperature is low. However, the variation in England is only small, and in practice it is not found necessary to make any adjustment for summer or winter. If required, on cars operating constantly under extreme conditions, such as met with in, say, Canada or India, an adjustment can easily be made by moving the expansion chamber closer to or away from the source of heat, i.e. the exhaust manifold. The clip which secures the chamber to the manifold is usually of such a construction that it can be easily modified to make this adjustment.

Construction of the Thermal System

The construction is simple and can be described in a few words—in fact, the illustration in Fig. 8 is practically self-explanatory.

The reservoir is of either glass or metal. It holds a little over 1 pint. The filler cap is on the top and an outlet connection at the bottom. There is no valve in the outlet—it is merely a "straight-through" nipple. A pipe is taken from the reservoir outlet to the expansion-chamber inlet valve. The expansion chamber is made of steel. The outlet valve is screwed into the top and the inlet into the bottom. They are clearly stamped "out" and "in" respectively, to distinguish them. The valves consist of a brass body, screwed externally at both ends; inside is a ball held on to a seat by a light spring. A pipe is taken from the outlet valve to the chassis distribution system; the latter is the same as that used in the vacuum system already described.

MAINTENANCE AND SERVICE OF THE THERMAL SYSTEM

Maintenance

Replenish the reservoir when necessary with Luvax Bijur Chassis Oil or an alternative approved by the makers, or by the manufacturers of the car to which the system is fitted.

Do not allow the reservoir to become empty. If, however, this has inadvertently occurred, it is advisable, when refilling, to prime the system. Although, given time, it will automatically prime itself, it may take several hundred miles' running to do this. When priming, unscrew the connection at the base of the reservoir, and attach the priming pump to the end of the pipe; this ensures that the feed pipe from reservoir to expansion chamber, the expansion chamber, and the distribution lines will all be primed. Force oil through until it is exuding from each bearing.

Give an occasional glance at the chassis bearings and see if oil is reaching them—a slight wetness should be visible externally. If the system does not appear to be delivering oil correctly, proceed as described below under "Service."

Service Repairs for the Thermal System

If all the bearings are dry, indicating that oil is not being delivered from the expansion chamber, examine the pipe and joints between the reservoir outlet and the expansion-chamber inlet valve. It is imperative that this connection is airtight, otherwise, when the oil in the expansion chamber contracts, air will be drawn in, instead of oil, from the reservoir.

Should it be found that the trouble was not caused by an air leak in the supply line, remove the inlet and outlet valves and see that they are not choked up. If necessary, flush them through with paraffin.

To test the outlet valve to see that it holds pressure correctly, grip it in a vice, and apply the nozzle of an oil-gun to the end to which the pipe attaches. If the ball is seating correctly, it will not be possible to force oil through.

A convenient method of testing the inlet valve is to hold the expansion chamber in a vice, with the inlet valve screwed into position, but the out-

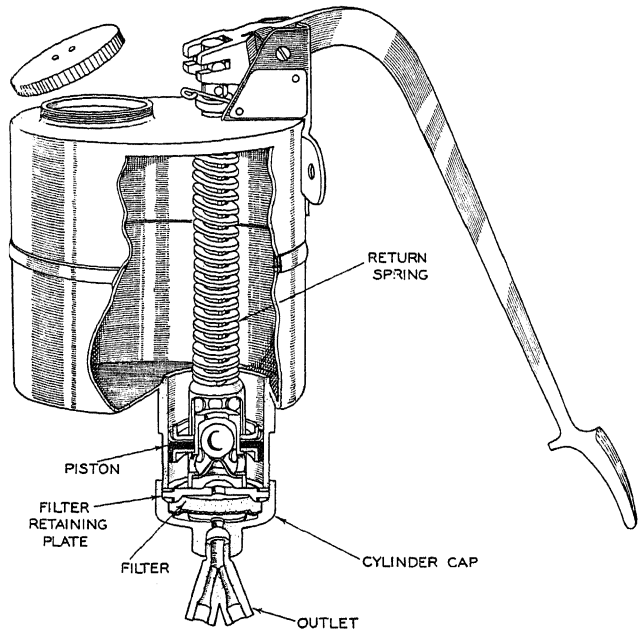


Fig. 9.—COMBINED RESERVOIR AND PUMP UNIT OF LUVAX BIJUR MANUALLY-OPERATED CHASSIS LUBRICATION SYSTEM

let valve removed. Insert the nozzle of an oil-gun into the hole from which the outlet valve has been removed, and force oil under pressure into the chamber. If the ball in the inlet valve is seating correctly, it will hold the pressure and prevent oil from exuding.

If either of the valves is faulty, a replacement should be obtained from the makers.

When refitting the valves to the expansion chamber, remember an air-tight joint must be made. It will be found advantageous to screw-in each valve, until one complete thread is holding, then add a drop of Hermetite, or some such jointing material, to the remaining threads before screwing the valve home. Make sure that when assembled into position on the car: the outlet valve is on the top and the inlet at the bottom.

After any attention which has necessitated disconnecting the system, it is advisable, on reconnecting, to " prime " as already described under " Maintenance."

As the meter valves and connection fittings are similar to those used with the vacuum system, the same service instructions are applicable.

THE LUVAX BIJUR MANUALLY-OPERATED SYSTEM

Description

The manually-operated system is similar to the vacuum-operated, with the exception that the pump unit is operated by a foot pedal.

The reservoir and pump form a combined unit, which is usually mounted on the engine side of the dashboard with the operating pedal protruding through at a convenient position for the driver's foot. A depression of the pump pedal causes about an egg-cupful of oil to be discharged under pressure into the pipe line. The number of pump-pedal

operations necessary to maintain the chassis bearings in good condition depends, of course, upon the number of bearings which the system is lubricating. On the average installation one "shot" every 100 miles is satisfactory.

Construction and Operation of the Manually-operated System

The combined reservoir and pump unit is shown at Fig. 9. The pedal is mounted on a fulcrum pin. When the pedal is depressed it raises the piston in the cylinder and at the same time compresses the return spring. Whilst the piston is being raised, oil is drawn through a ball valve, in its centre, to the underside. When the driver's foot is removed from the pedal, the return spring forces the piston downwards. The pressure on the oil below the piston closes the ball valve, thus preventing return flow through the piston, the oil consequently being forced downwards through the filter and out of the pump outlet. The spring is of considerable length, and is so rated that the pressure is practically constant throughout the stroke. The time period during which the piston descends, depends upon the thickness of the oil. On a cold day it takes a little longer than on a hot day; the amount of oil delivered, however, is the same under all conditions, it merely means that the period of discharge is longer at low temperature. The average time taken is 5 minutes.

Owing to the slow flow, the filter can be sufficiently dense to remove even the smallest particles of dirt without restricting the flow. When the piston reaches the end of its stroke, it effectively closes the hole in the filter-retaining plate so that oil cannot leak away whilst the pump is not being operated.

MAINTENANCE AND SERVICE OF THE MANUALLY OPERATED SYSTEM

Maintenance

Replenish the reservoir when required with Luvax Bijur Chassis Oil or an alternative approved by the makers or by the manufacturers of the car to which the system is fitted. Do not allow the reservoir to become empty.

Operate the pedal every 100 miles or as often as recommended by the car manufacturer. After pressing down the pedal, release it suddenly by removing the foot smartly.

If after depressing the pedal it returns rapidly to its normal position, i.e. in less than 1 minute, it indicates that either the reservoir is empty or there is a fault in the system. If the reservoir is empty, refill it, then operate the pedal until it takes the usual time to return to the normal position. If the quick return of the pedal is not due to an empty reservoir, proceed as per instructions given below under "Service."

Service of Manually Operated System

Here are some of the faults which may have to be dealt with, and their remedies:

All Chassis Bearings Dry

This may be due to the user having neglected to operate the pump pedal or to the reservoir being empty. Ascertain that the reservoir contains oil, and then operate the pedal two or three times and see if oil appears at the various bearings. If with a full reservoir the pedal returns rapidly to the normal position, after being pressed down, it indicates an uncoupled or leaky connection or a broken pipe or alternatively a faulty pump unit. The former may be easily spotted if the pedal is operated four or five times, as all the oil discharged by the pump will be forced out of the broken or leaky connection on to the floor and a pool will form. The pump unit may be tested as follows : if found faulty fit a new one ; do not attempt to dismantle the old one, as special tools are required and must be used, otherwise damage will result.

Testing the Pump Unit

Disconnect the chassis oil line from the pump outlets. Then close the outlets by screwing in solid plugs or by connecting short pieces of pipe with the outer ends hammered flat. The pedal should now be pressed down. With the outlets plugged as described, the piston should hold the pressure ; if, therefore, the pedal shows a visible upwards motion during a period of 2 minutes it indicates a leak past the piston, either past the cup leathers or through the ball valve. Too thin an oil in the reservoir will give this effect, therefore examine the oil and if necessary replace with the correct grade. If the oil is found to be correct, then the fault lies in the pump and a new one should be fitted.

A case may be met with, occasionally, where the pump lever fails to return to its normal position after being pressed down. This may be due to the filter having become clogged, caused by the use of dirty or improper oil. To clean the filter, proceed as follows : Disconnect the chassis oil line at the pump outlets. Then depress the pump pedal and block it in a partially depressed position, with a piece of wood wedged against the instrument board or some such means. Unscrew the cylinder cap on the underside of the reservoir, but take care to have a tin handy, to catch the oil which will run out. Note the position in the cylinder cap of the filter-retaining plate, with its gaskets, before dismantling. Then lift these out, exposing the felt filter disc, which should be removed and washed in petrol until clean and white. There will be found beneath the felt disc in the cap a wire gauze disc. This should be left in position with the ridges against the cap. When reassembling, replace the felt disc and then the filter-retaining plate and gaskets, with the hollow side of the plate facing the felt disc. Be sure that both the gaskets are in the correct position. The cap assembly is now ready to be replaced on the cylinder.

Faults in the junction-pieces and meter valves may be remedied, as already described for the vacuum system. After reconnecting the system, it should be primed until oil is exuding from each bearing.

SERVICE AND REPAIR NOTES ON GILFORD "HERA" 32/29 PASSENGER VEHICLES

The Front and Rear Axles, Steering, and Brakes

By S. E. SMITH

FRONT AXLE

THE front-axle unit fitted to the Gilford "Hera" chassis is of orthodox design and incorporates, as necessary for heavy passenger vehicles, very efficient front-wheel brakes. The brake shoes have large-diameter linings 3 in. wide, which provide ample friction surface, and if the brakes are kept properly adjusted very little attention will be found necessary as regards the brake mechanism.

The swivel or stub axles have parallel pins running in bronze bushes and Timken bearings, and these should be kept very carefully lubricated and periodically checked for wear. The Timken bearing at the top of the swivel pin should be

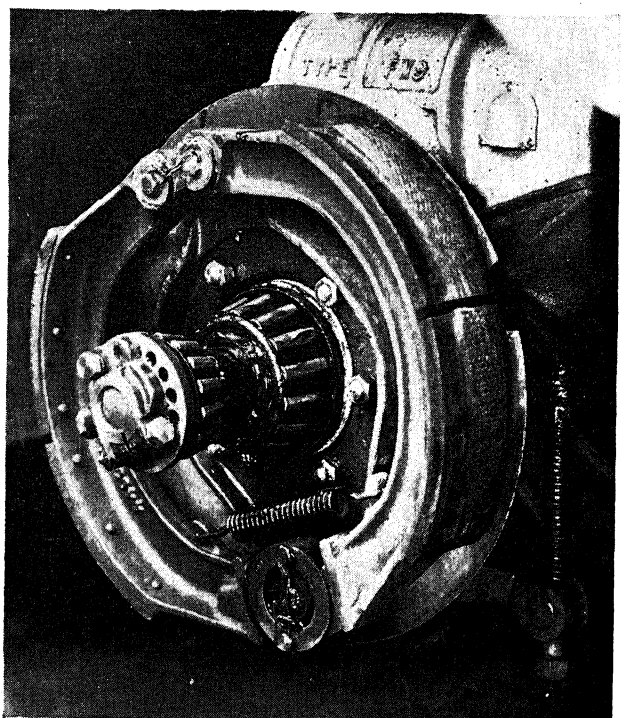


Fig. 1.—THE ASSEMBLY OF THE FRONT HUB BEARINGS, LOCKING WASHERS, AND NUTS

frequently examined, and adjusted as required to take up any slackness which may be present.

To-day the public-service vehicle examiners and certifying officers responsible for the proper mechanical fitness of all public-service vehicles are particularly alert for any wear or defects as regards the front axle. This, of course, can be readily understood, when the important functioning of this unit, particularly in relation to the steering, is considered.

In the circumstances it cannot be emphasised too strongly how essential it is to maintain in first-class manner the front axle and its subsidiary parts.

Overhauling Front Axle

When it becomes apparent by the " play " in the front wheels that new stub-axle pins and bushes are essential, it is strongly advisable to remove the whole front-axle unit complete from the chassis. The procedure to be carried out should be as follows :

Disconnect and remove the steering drop arm from steering arm, also disconnect the servo pipes from the two servo units situated at each end of the axle. Remove next the front-spring shackle bolts, and the front axle will then be free and can be wheeled away from the chassis.

Dismantling

The order of dismantling is to first remove the wheels and hub caps. The special hub nut at each end will then be exposed ; but before these can be taken off it will be necessary to remove the split-pin, special locking bolts, and grub-screws, all of which are additional security in preventing any risk of the hub nut working loose under working conditions and perhaps allowing the wheel to come off, which would be a serious matter with any class of vehicle. After removing the hub nuts, next take off the special " D " washer, when the hub can be removed, together with the steel washers and oil-retaining felts.

The brake shoes come next in dismantling. Undo the two small bolts and plates fitted over the heels of the brake-shoe pivot pins, when the brake shoes can be slipped off.

Now undo the $\frac{1}{2}$-in. bolts which secure the brake-shoe dust shields, and take these off. Then remove the two servo units, when the stub pins and locknuts are exposed for attention. Take off the locknuts and washers, then knock out the cotter pins ; the stub-axle pins can now be extracted by tapping out downwards. The stub-axle Timken races and their shims should then be removed and the bottom bushes pressed out.

Fitting New Bushes

The new bushes should now be pressed in to the stub axles and carefully reamered out to suit the pins. In fitting these pins particular

care must be taken to ensure that they line up correctly with the Timken bearings, which are fitted at the top of the stub axle.

To carry on with reassembling, first of all fit each stub axle in position without any felt washers, and adjust the Timken bearings by means of the shims provided, so that the locknuts can be tightened down to leave the stub axles free to move, but at the same time without any signs of slackness. It will be necessary to remove or add shims as required to obtain this adjustment correctly. Having effected this procedure quite satisfactorily, next dismantle and reassemble again, but this time fitting at the same time the felt washers and retainers. It may appear on the second assembly that the stub axles are now tight, but as by the previous attention it is quite definite the races were adjusted correctly, any tightness found afterwards will be due only to the felt washers, which of course will very soon bed themselves and allow the stub axles to operate freely.



Fig. 2.—THE WORMSHAFT OIL-RETAINING GLAND AT THE FRONT OF THE DIFFERENTIAL BEING TIGHTENED BY MEANS OF A SPECIAL " C " SPANNER

The dust covers and brake shoes can now be reassembled and the hubs refitted. After fitting the hubs and races, fit the special " D " washers and hub nuts and nip up just tight. Then slacken back approximately one half-turn, and turn until the hole in the hub nut lines up with the hole in the " D " washer. Fit the grub-screw in hole, and then fit lockbolt through the hub nut and split-pin up. Completion of the

reassembling of the front axle to the chassis is then quite a simple matter.

REAR AXLE

The Gilford " Hera " rear axle is of the fully floating type and has the worm-driven differential unit fitted in the nearside of the axle casing, instead of the orthodox central-drive position. The reason for this is to obviate the obstruction of the differential lid causing difficulty in the gangway on passenger-type vehicles. With the differential offset to one side, the raised portion of the differential is in a position (probably under a seat or somewhere similar) in which it presents no difficulty to the body-builder as regards gangways, etc.

Axle Shafts

The two axle-driving shafts are of different lengths, due to the special design of axle, and consequently it is very important when ordering replacement shafts to stipulate whether the shaft required is for the nearside or offside. The shafts are fitted direct into the differential bevel wheels with a splined fitting and are secured at the hub ends by a splined driving dog. They can be easily removed by removing the nuts that secure the driving dog to the hub and also refitting is a simple matter.

In the event of an axle shaft breaking off short at the differential end, difficulty is sometimes experienced in removing the broken portion which is left in the differential. In such an instance, it will generally be found that the best way to remove this is to withdraw the opposite shaft and push a long bar right through the axle casing and thus eject the broken piece. Should this method fail to be successful, the only remedy is to remove the differential unit complete from axle.

To remove Differential

To take down the differential unit from the chassis it will first be necessary to withdraw both axle shafts and uncouple the Hardy Spicer coupling from the differential flange. It is then only necessary to remove the bolts that secure the differential to the rear-axle casing, and the differential is ready to be dropped. Before, however, completely removing all the securing bolts, the weight of the differential should be taken up on a jack and a rope fixed around the unit for lowering purposes. Having arranged this satisfactorily, remove the remaining securing bolts, and having taken the weight of the differential by means of the rope from above, through the trapdoor, remove the supporting jack and gradually lower the differential complete to the floor.

Differential

The differential is of very robust construction, both the wormshaft and wormwheel being rigidly mounted on large ball-and-roller bearings.

As a result there are no special adjustments to attend to after the differential is properly assembled. The only item that will require periodical attention is the oil-retaining gland at the front end of the differential, which may, when wear develops, allow oil to creep through. This can then be remedied by tightening up the special slotted gland nut by means of a suitable "C" spanner so as to rebed the special packing fitted in the gland itself (*see* Fig. 2).

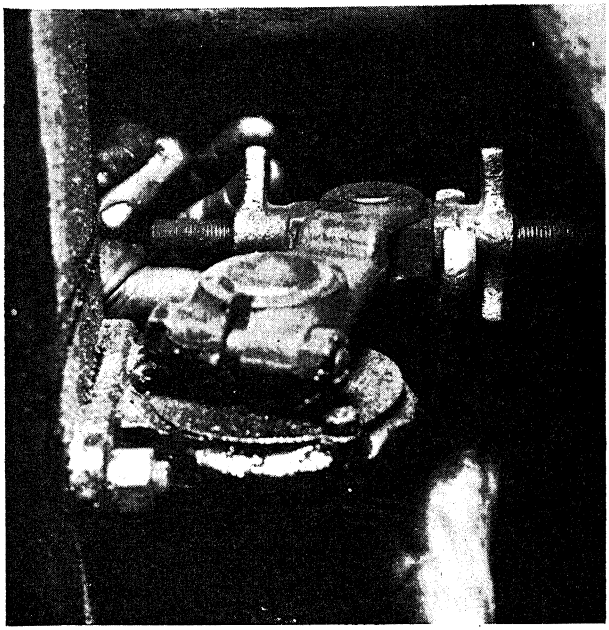


Fig. 3.—MASTER ADJUSTMENT FOR FOOT BRAKE
The locknut behind the turnbuckle is slackened, and re-tightened after adjustment has been taken up by means of the flynut.

When tightening up the gland nut does not prevent oil leaking, it is then obvious that a new packing is required.

Rear Hub Removal

To remove one of the rear hubs, first of all take off the wheels and withdraw the axle shaft. When this is done the special hub-locking device is exposed, and it will be seen to be very similar to that employed with the front hubs, excepting that the construction is much larger. The next operation is to remove the split-pin from lockbolt and withdraw locking bolt; after this extract the special set bolt which locks the adjusting collar to the "D" washer. Now it is necessary only to unscrew the adjusting collar and remove the "D" washer, when the rear hub is ready to be removed complete with bearings.

To reassemble Rear Hub

After fitting on the rear hub together with the Timken bearings, fit up next the special "D" washer and locking nut and fasten up quite tight. Then carefully slacken back the nut approximately one half-turn until the hole in the hub nut coincides with a hole in the "D" washer. Then screw the set bolt in position, which will lock properly this adjustment

for the bearings. Now all that remains is to fit the locking bolt into the adjusting collar, which will pull the split collar together and lock it securely on the threads of the axle tube. Then split-pin up and hub is double-locked in position.

STEERING

Adjustment

The steering gear is of the Marles type, which is, generally speaking, very troublefree. There are, however, two adjustments which may at some time need attention. The first adjustment concerns the roller assembly in relation to the cam. To raise or lower the mesh of these two parts the following procedure should be followed. Remove drop arm from rocker shaft and rocker shaft from steering box. Take off nut and washer from rocker-shaft bolt and withdraw bolt from rocker-shaft serrations, until serrations on bolt are just free of the rocker-shaft serrated hole. This will mean withdrawing the bolt about $\frac{3}{8}$ in. to $\frac{9}{16}$ in. With an ordinary spanner on head of bolt, turn bolt one serration or more as found necessary in a clockwise direction for raising the roller into the cam, or in an anti-clockwise direction to lower the roller away from the cam. Push bolt home again into rocker shaft and refit nut and lock-washer carefully in position. It should be noted that to raise the roller relative to the centre line of the rocker shaft, giving deeper engagement with the cam track, the bolt must be turned clockwise looking at the end of the bolt.

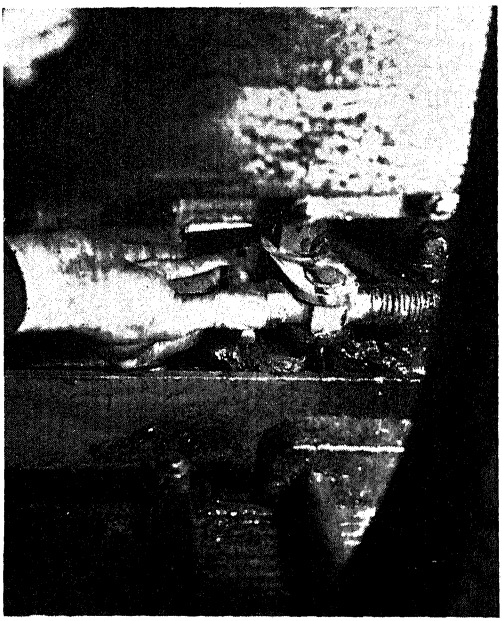


Fig. 4.—ADJUSTMENT OF THE HAND BRAKE

When this adjustment is correctly made it will be found that there is a slight amount of "backlash" at the two extreme ends of the cam and roller movement, but absolutely none in the centre or straight-ahead position. Care should be taken that the roller is not advanced so far into the cam that movement is stiffened. On the other hand, the adjustment must be close enough to ensure no trace of "backlash" in the central position of the cam and roller.

The second adjustment is between the steering-box and the column support.

Between the steering-box casting and the column support are a number of thin washers or shims. End play of the cam between its bearings may therefore be taken up by taking out some of the thin layers and thus allowing the thrust cone carried by the column support to enter farther into the steering box and thus come closer to the cam.

When this adjustment has been correctly made it should be such that after the column support is again bolted securely to the steering-box casting, the cam and steering-wheel shaft should revolve freely, but there should be no end play of same.

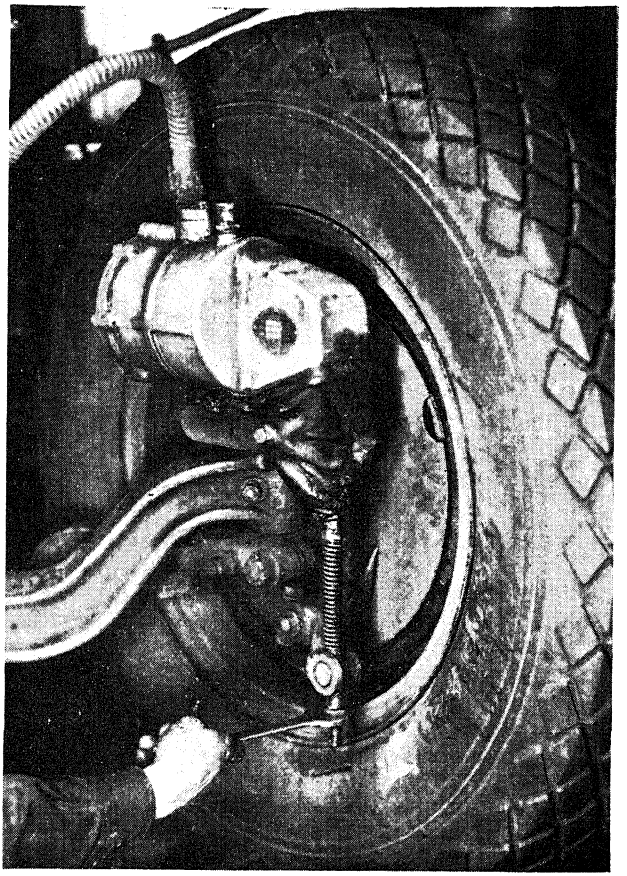


Fig. 5.—METHOD OF ADJUSTING THE FRONT WHEEL BRAKES

Between the steering box and bottom cover similar shims are inserted as those between the steering box and column support. These bottom shims, however, should not be disturbed, as they are correctly set by the manufacturers and are for the purpose of centring the cam relative to the rocker shaft.

Special Note.—Do not drive drop arm on to rocker shaft when reassembling. This should always be pulled on by nut at end of shaft. Do not interfere with the lockstop in the steering box.

Steering Track

The steering track rod is screwed right-hand and left-hand at each end for necessary adjustment. The correct front-wheel "toe-in" should be not more than $\frac{1}{8}$ in.

BRAKES

The braking system is very simple, and is assisted by a triple servo system which ensures very effective operation of the brakes at all speeds.

There is one pair of brake shoes in each hub, the rear shoes being 6 in. wide with a very large friction area. These shoes operate for the hand-brake as well as for the foot, and, due to the special design of link-up incorporated, the results are very good.

The Servos

The triple Dewandre Vacuum Servo system consists of a master or main cylinder and piston which controls two smaller cylinders. The master cylinder applies all its effort to the rear wheels alone, and is provided with a special valve (this is the only valve in the whole system), the two smaller cylinders being merely connected to this main cylinder by means of suction pipes and having no valves of any kind.

The master cylinder is coupled by means of a suction pipe to the induction pipe of the engine and controls the two supplementary cylinders, which are fitted to the front wheels. There is no mechanical connection between the front and rear brakes except by the suction pipes.

All details of the operation, etc., are dealt with in a separate article solely concerned with these units.

Adjustments

The foot-brake pedal is connected to the main servo, and from there the brake rods continue to a cross-shaft, thence to two special fulcrum levers, and finally finish with short rods to the rear-brake cam levers. The main adjustment for the foot-brake is by means of a master turn-buckle, which will be found about half-way along the chassis. This can usually be reached quite easily through the trapdoor provided in most coach bodies (*see* Fig. 3). Should it be necessary to equalise the brakes, this should be undertaken by adjustment on the short rods which go to the cam levers.

The adjustment for the hand-brake can be made by means of a large flynut which is fitted at the bottom of the hand-brake lever. This is easily accessible through the trapdoor in the driver's cab (Fig. 4).

If found necessary, individual adjustment can be made at each front wheel. There will be found provision for this adjustment at each of the front-wheel servo units, by means of the two short rods which connect these units to the front-brake cams (Fig. 5). No special care is necessary to balance the front-wheel brakes with this system. The adjustments should be just sufficient that when the shoes begin to rub, the adjusting nut is released by approximately half a turn. In making this adjustment care must always be taken to ensure that the front brakes are doing their full share of braking. The rear brakes will naturally give much longer

life and require less attention if the fronts are kept properly adjusted and are as a result working in correct harmony with the rear.

Special Note

It is important that the length of brake-rods is not altered. This applies particularly to the rod between the brake pedal and servo. This rod is carefully determined by the manufacturers when the vehicle is built, and there should be no need to interfere with same in the ordinary way.

TRANSMISSION

The transmission from the gearbox to the differential is arranged by large-diameter tubular propeller shafts incorporating Hardy Spicer universal joints, with the exception of the coupling immediately to the rear of the gearbox, which is a metal-enclosed Layrub type of universal joint.

The Layrub type of joint needs no attention at all as, being fitted with rubber bushes of special construction, there is no lubrication to worry about, or oil retainers, etc., to renew periodically. The time does eventually arrive, however, when the rubber bushes or metal joint holes become distorted through extensive usage, when a new joint becomes necessary. It is possible, if the joint has not gone too far, to renew the rubber bushes only, but this is a matter for the makers to deal with.

The remaining universal joints are, as previously stated, of the Hardy Spicer type and need very little attention, excepting careful and regular lubrication, which is effected by packing with the special grease recommended by the makers. Occasionally, these joints should be inspected to ensure that the cork gasket fitted to the casing retainer is sound and does not allow the grease to leak. If there is any doubt about this, the coupling should at once be removed and fitted with a new grease-retaining cork. Lack of lubrication to these joints can prove a very expensive matter.

Centre Carrier

The centre carrier is mounted on a chassis cross-member and consists of a very large and self-aligning ball race encased in a suitable housing. The front propeller shafts run direct to this assembly. The only attention the centre carrier needs is frequent lubrication, which is carried out by gear oil from the Tecalemit battery nipple situated on the nearside rear cross-member.

THE REPAIR AND MAINTENANCE OF ALL-STEEL BODIES

By A. F. HOULBERG

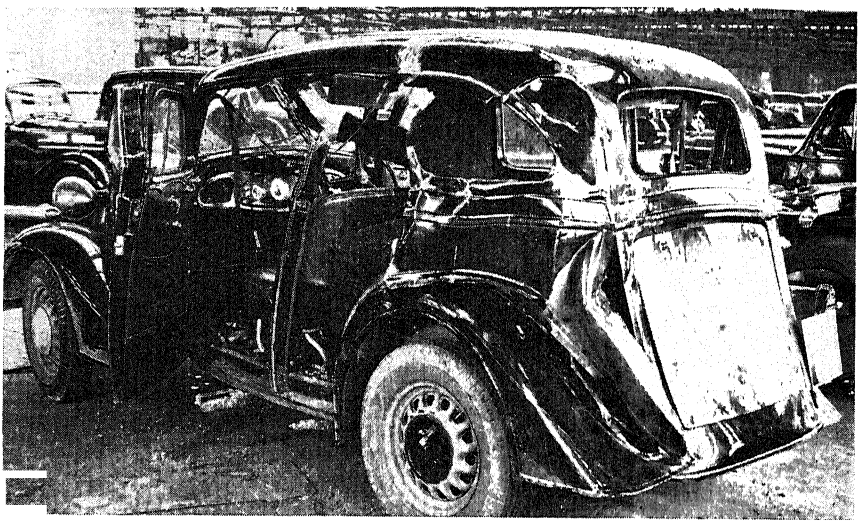


Fig. 1.—AFTER THE SMASH

This shows a Vauxhall Car of integral construction. The repair is illustrated in the following Figs. 2 to 8. A trimmer is shown in the above picture removing the interior trimmings. (*By courtesy of Shaw & Kilburn.*)

IN order to be able to carry out repairs effectively, an understanding of the basic constructional features of the all-steel body is essential.

The earlier all-steel bodies—those made prior to 1936 by the Pressed Steel Co.—consist of four main sub-assemblies which are welded together. The four sub-assemblies consist of:

(1) The scuttle assembly, which includes the windscreen frame and the front door pillars—or "A" posts, as they are often referred to.

(2) The right-hand side panel assembly, which includes the centre door pillar or "B" and "C" post, the rear door hanging pillar or "D" post, the rear-quarter panel, and the top and bottom sills.

(3) The left-hand side assembly, which is similar to the above.

(4) The rear panel assembly.

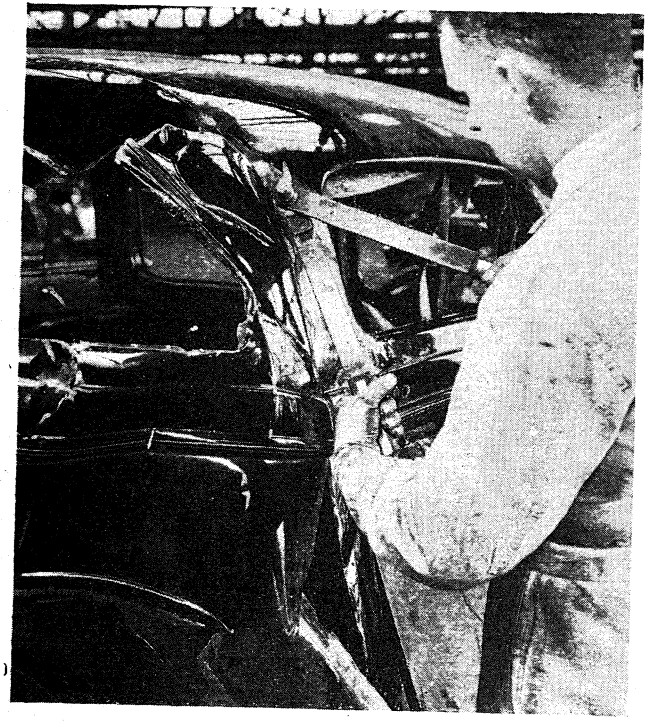


Fig. 2.—THE REPAIR—FIRST OPERATION
Cutting out the smashed section with shears (quarter panel). (*By courtesy of Shaw & Kilburn.*)

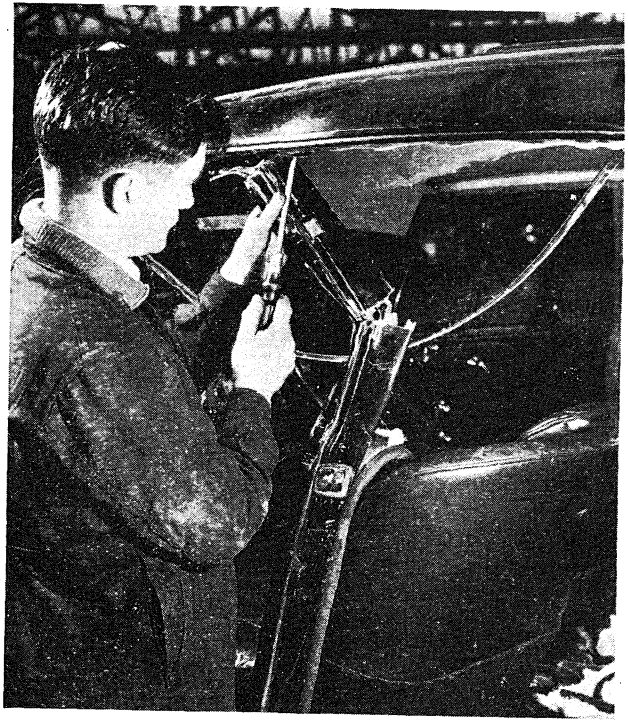


Fig. 3.—THE SECOND OPERATION
Removing the damaged centre pillar. (*By courtesy of Shaw & Kilburn.*)



Fig. 4.—THE THIRD OPERATION

Beating out edges of damaged portions of rear panel with planishing hammer and dolly. (*By courtesy of Shaw & Kilburn.*)

The later models are built up from five sub-assemblies, made up of:

(1) The right-hand side assembly, consisting of the scuttle side, the front pillar or "A" post, the centre pillar or "B" and "C" post, the rear pillar or "D" post, the rear-quarter panel, and the top and bottom sills.

(2) The left-hand side similar to the above.

(3) The rear panel assembly.

(4) The scuttle top panel.

(5) The wind-screen peak panel.

A still later type of all-steel body, employed, for example, on the Morris Ten (series "M"), is of monopiece construction, i.e. it has its chassis built as an integral part of the body. The repair of this type is dealt with later, as there are certain differences in procedure.

Dealing first with the normal type of construction, all component parts of the sub-assemblies are made from steel, mainly in the form of pressings, and welded together by one of three welding methods. These are oxy-acetylene welding, electric-resistance or spot welding, and electric arc welding. The type of welding used depends on the nature of the parts to be joined together and the nature of the joint.

The electrical methods of welding have certain advantages, but suffer from the fact that the apparatus is expensive and beyond the reach of all but the very largest repair establishments.

For the purpose of repair work, the oxy-acetylene method is perfectly satisfactory and has the advantage of low cost and ready portability.

OXY-ACETYLENE WELDING REPAIRS

The principles of oxy-acetylene welding are dealt with elsewhere and it is not necessary to repeat them here, but there are one or two points,

arising from the fact that the material to be worked on is thin, and the construction of the body, which need consideration.

Whilst a weld is being carried out, heat is being conducted away from the region of the weld to the surrounding portions of the structure, causing them to expand, and owing to their comparative thinness they are liable to buckle and distort unless precautions are taken.

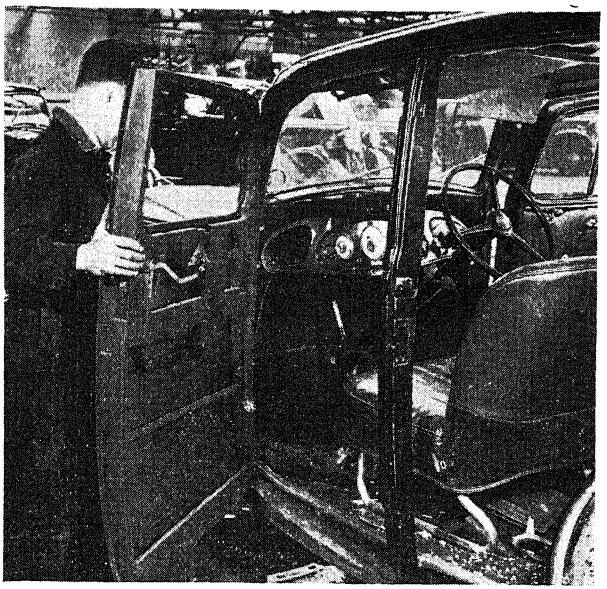


Fig. 5.—THE FOURTH OPERATION

Fitting new front door after new centre pillar has been fitted. (*By courtesy of Shaw & Kilburn.*)

Sound welds, accompanied by the minimum amount of distortion, can be made only by those possessing a sound working knowledge of the correct use and adjustment of the welding equipment. A study of the basic principles of the process should be made and considerable practice carried out with scrap metal of the same quality and thickness before any attempt is made to carry out any important welds.

First remove Solder

In many places on all-steel bodies solder is made use of for the purpose of filling gaps and irregularities on the surface of the body. Before a satisfactory weld can be made on metal so treated it is absolutely essential to remove all trace of the solder.

This is best accomplished by melting away the soldier with a blow-lamp as far as possible, and, while the metal is still hot, wiping away the remaining solder with a clean rag. A file or suitable scraper should then be used to remove the last traces of solder, so that perfectly clean steel surfaces are left for the welding process.

Welding Tip Sizes to Filler Rods

The correct choice of the welding tip is of great importance when operating on this material, for if the tip is too large the finished weld

will be very hard and will show a porous surface, while too small a tip will not produce proper fusion and will give a weld of low strength. A tip consuming approximately 200–300 litres or 7–11 cu. ft. of acetylene per hour will be found satisfactory for most work on a welded-steel body. The use of the correct size of tip will also minimise warping.

The employment of a filler rod of the correct size is also important. Should the rod be too large, the metal being welded will often burn before the filler rod becomes molten, while too small a rod will produce the reverse condition—the rod burning before fusion of the weld takes place.

The sheet metal employed on all-steel bodies requires the use of a filler rod of the purest possible iron, with a low carbon

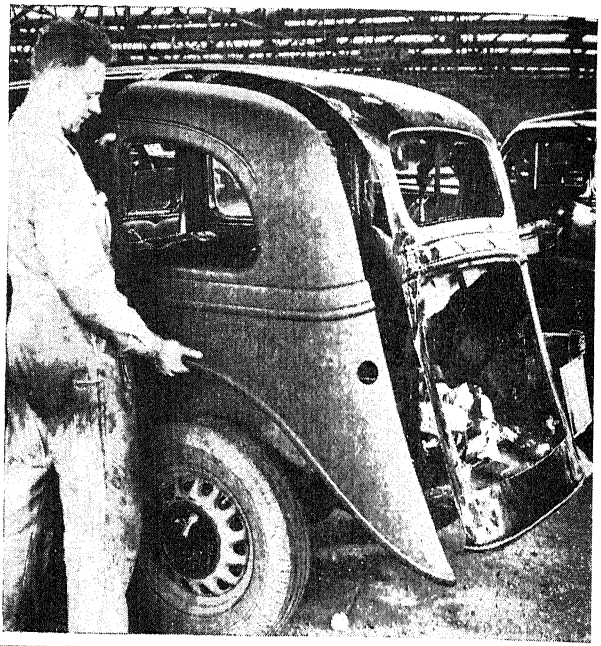


Fig. 6.—THE FIFTH OPERATION

Placing new quarter panel section in position after beating out and reshaping rear panel. (*By courtesy of Shaw & Kilburn.*)

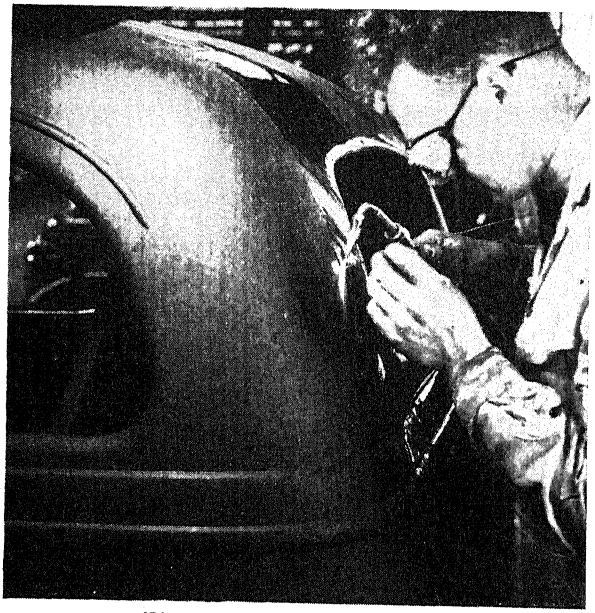


Fig. 7.—THE SIXTH OPERATION

Tacking the new panel in position with oxy-acetylene blowpipe. (*By courtesy of Shaw & Kilburn.*)

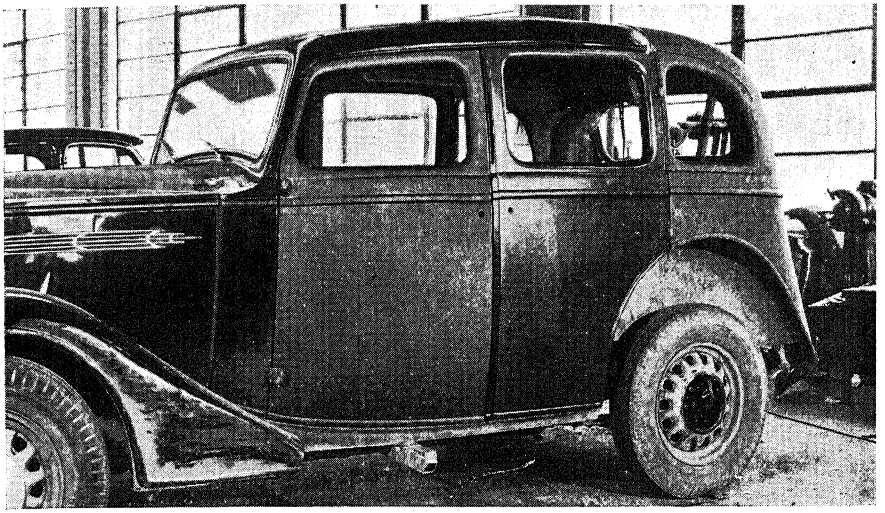


Fig. 8.—THE BODY REPAIR NEARING COMPLETION

Showing quarter panel and doors fitted. The integral construction of the Vauxhall car shown above consists of two quarter panels, left and right, rear body panel, roof side panels, left and right, and scuttle panel. (*By courtesy of Shaw & Kilburn.*)

content. That recommended is the one marketed and guaranteed as being 99·84 per cent. pure iron.

When welding, take care to keep the filler rod clean and free from contact with rust, as this is an enemy to a good weld. Welding rods should be kept in a dry place and be free from rust when used.

Welding Hints

The flame should be adjusted to neutral, i.e. neither oxidising nor carburising, and should be applied to the weld at an angle of approximately 70°, with the point just touching the metal. The filler rod should not be applied to the weld until the metal of the weld is completely molten, and when applied should be brought into direct contact with the molten metal and not dropped into the weld by pre-melting in the welding flame.

It is most important that the flame should not bend or spread over the sides of the weld when it is brought into contact with the weld. The point of the flame should be held in such a position that the outer end of the bright cone just licks the metal.

How to prevent Buckling

It is essential that buckling or warping should be kept to a minimum, in order to avoid further corrective repair work.

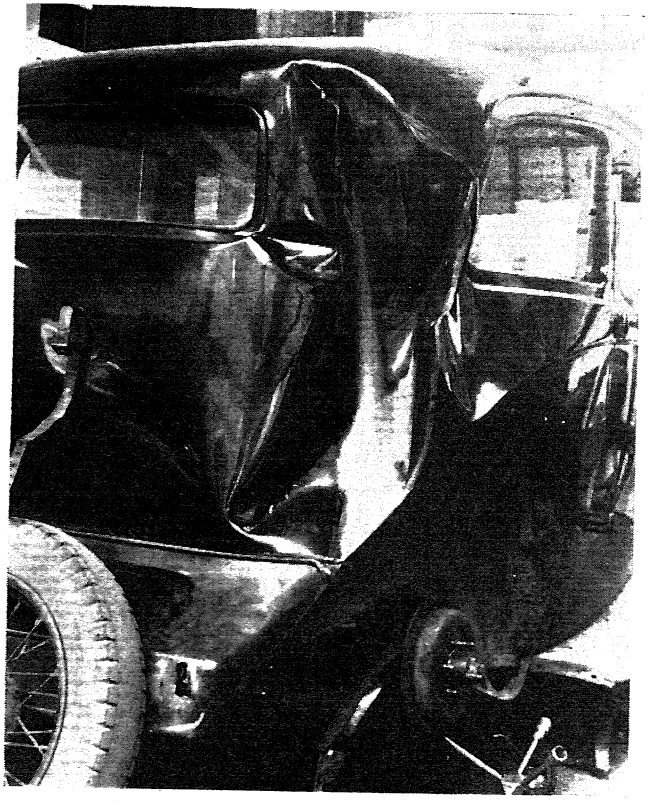


Fig. 8A.—REPAIRING DAMAGED BODY WITHOUT REPLACEMENT OF PARTS

This is an untouched picture of a smash, and Fig. 8B shows what can be done without replacing any panels.



Fig. 8B.—REPAIRING DAMAGED BODY WITHOUT REPLACEMENT OF PARTS

The panel was dressed out with hammer and dolly. No metal filling used, only the ordinary cellulose filler before cellulosing.

(Both pictures by courtesy of Messrs. L. F. Dove, Ltd., Croydon.)

The use of wet asbestos sheeting placed along each side of the weld about $\frac{1}{4}$ in. from the edge of the metal will help to localise the heat and prevent undue distortion. The work should also be "tacked" at frequent intervals with a weld of from $\frac{1}{8}$ in. to $\frac{1}{4}$ in. in length, to ensure that the components are in their correct relative position and further reduce distortion.

The use of wet asbestos sheet when carrying out welds on work that has already been finished or partly finished is also recommended, as this reduces the area of discoloration round the weld and the amount of repolishing required subsequently.

REPAIRING DAMAGED BODY

Some Essential Tools

All-steel bodies seldom fracture even in severe accidents, and they may often be saved for further use if correctly treated in the first instance.

One of the most useful tools for preliminary attention to a damaged body is the body jack, or stretcher. These tools are obtainable from Harvey,

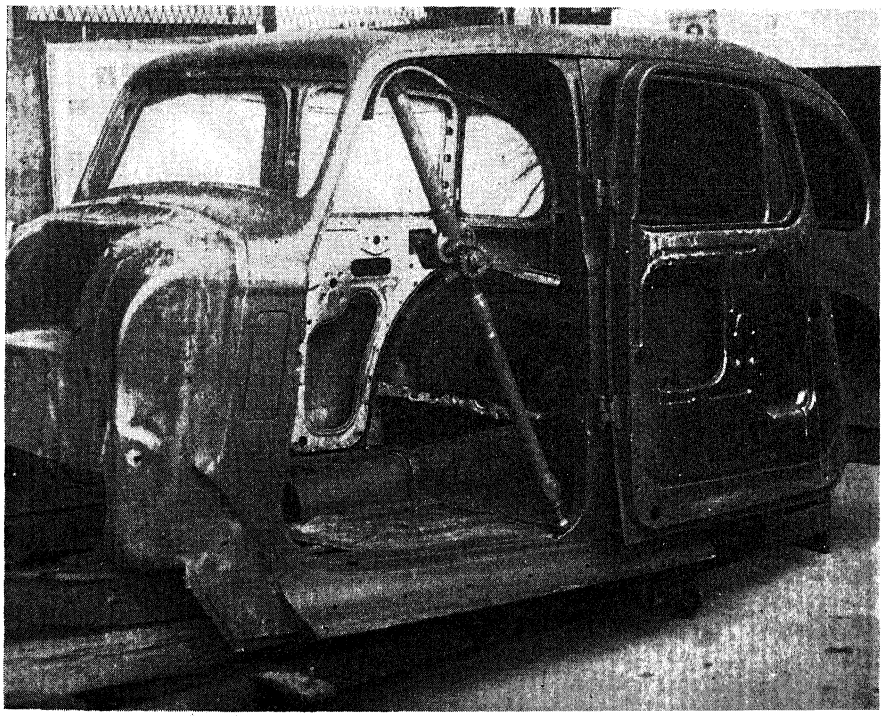


Fig. 9.—A BODY JACK IN USE, TO SQUARE UP A DOOR FRAME

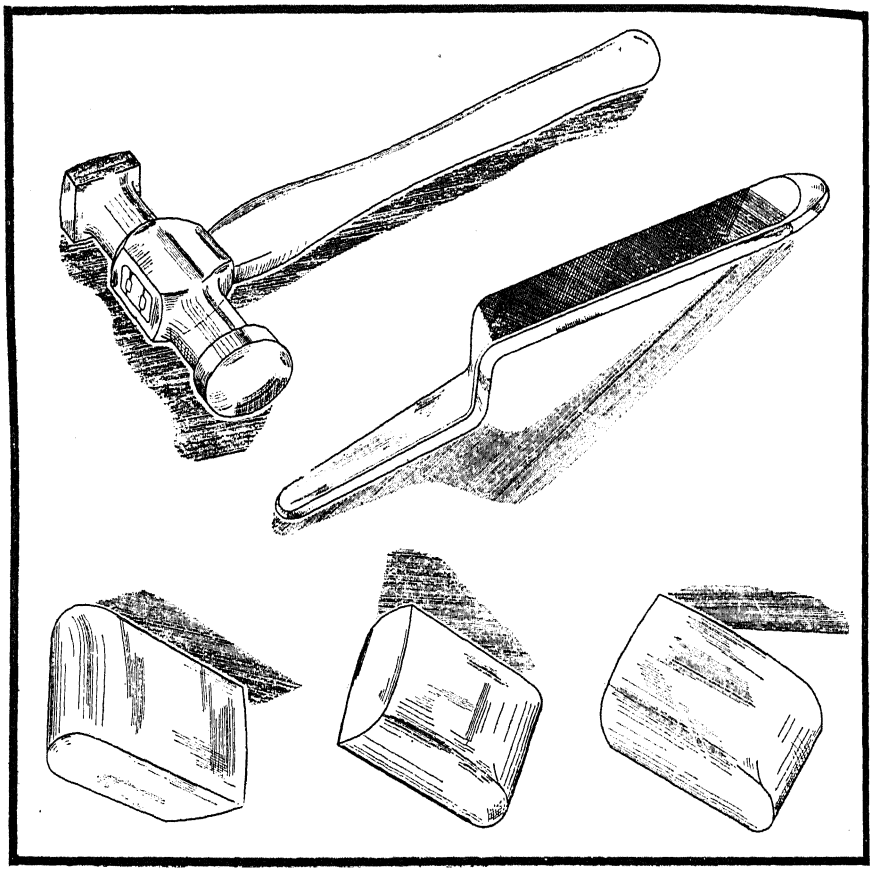


Fig. 10.—SOME OF THE NECESSARY STRAIGHTENING TOOLS FOR TAKING OUT DENTS IN WINGS AND PANELS

Showing pein hammer, various shaped dollies, and a paddle made from an old milling file.

Frost & Co., of 150 Great Portland St., London, and consist of an extensible jack with a range from 24 in. fully contracted to 96 in. fully extended, to which may be attached variously shaped end fittings, or dollies, which are specially adapted to push out damaged panels or square up distorted bodies. The detailed use of this tool will be described later.

A set of sheet-metal working tools, consisting of a wooden mallet, hide hammer, planishing hammer, bumping hammer, various shaped dollies, files, file with cranked handle for finishing large flat areas, cranked paddle (made from an old heavy milling file), twisting wrenches, drift pin, lifter, and scribe awl.

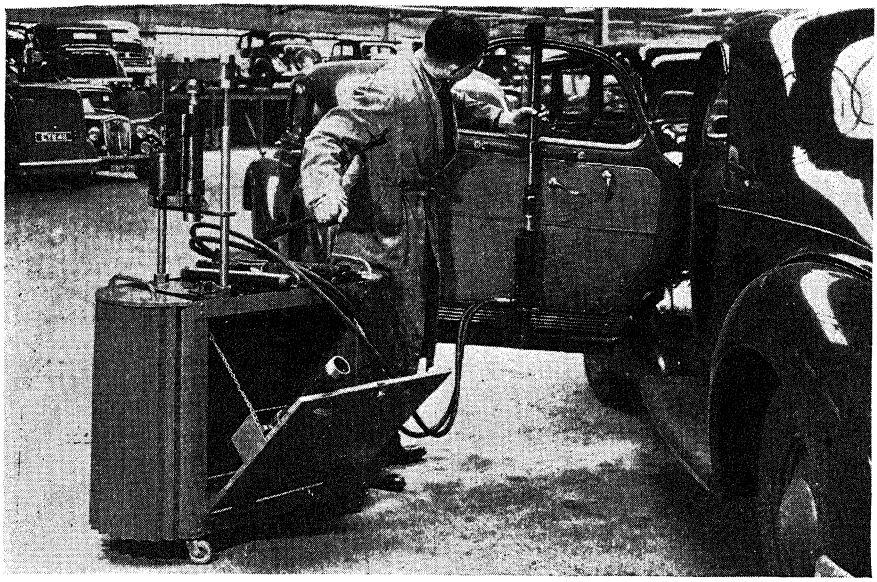


Fig. 11.—USING REMOTE CONTROL HYDRAULIC JACK

Top of door being pulled back into position. The jack is being operated at a distance by means of special hoses. (*By courtesy of Equipments Ltd.*)

The First Operation on Damaged Body—Checking Alignment

Most bodies which have been involved in an accident of any consequence are distorted in some way, and the first essential is to check up the alignment of the body and correct any portion which has been forced out of square by the impact.

Check up the door openings, the "A," "B," "C," and "D" posts for squareness, also the windscreen panel.

Removing the Trimming

Before applying any corrective measures to the body it is essential to remove any trimming in the locality of the damage which may interfere with the operation.

Most of the trimming is built up on a millboard foundation, which is covered with the upholstery material and either tacked in place or attached to the body by snap fasteners.

The door trim panels are fastened to the body of the door by snap fasteners in the majority of cases, and are released by inserting a screwdriver under the head of the fastener and prising it outwards. Care should be taken when doing this not to tear the upholstery. On some cars the door-window moulding must be removed before the trim panel can be detached, while on other models the door inside trim plate cannot

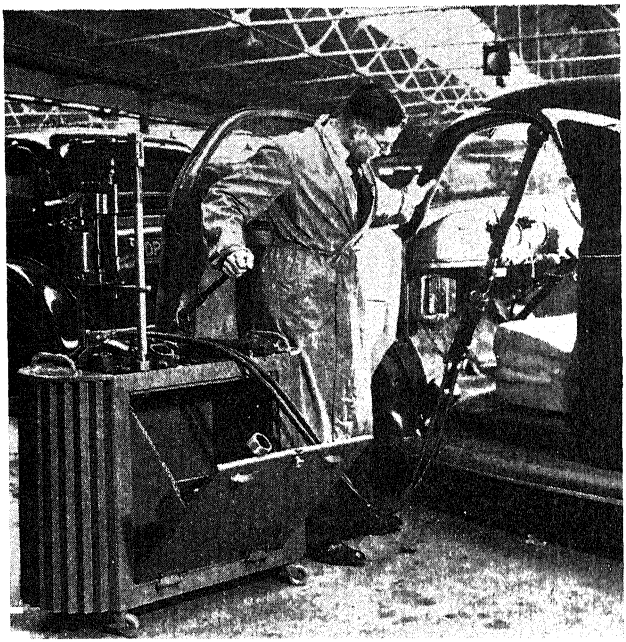


Fig. 12.—USING REMOTE CONTROL HYDRAULIC JACK FOR PUSHING TURRET TOP OF CAR OUT AFTER ACCIDENT

be removed until the trim panel is withdrawn, when it can be unclipped from behind.

The centre pillar trimming is built up in a similar way to the door trimming, but is fastened by gimp pins, which are driven into strips of paper-cord filler fixed to the pillar. On some models the panel is held to the pillar by drive screws, and where this method is used it will immediately be apparent.

The lower-quarter trim panels are held in position by a series of tacks along their top edge, and down the rear door pillar. They can be prised off after removing the tacks and the window moulding.

The scuttle trim panels are carpet panels, and are held in position by tacks, which are driven into the special trimming strips attached to the door pillar. On some models these are found to be attached by a screw, a bifurcated rivet, and a series of gimp pins, all of which must be removed before the panel can be withdrawn.

Windscreen and Side Headers

Later models have these components attached by drive screws driven into the windscreen top rail and gimp pins driven into the roof flange. Drive screws and gimp pins must be removed and the front end of the side headers must be raised to give access to tacks fastening the windscreen headcloth in position.

Earlier models have their headers fastened in position by brads driven into trimming strips attached to the panelling.

Headcloth

The headcloth material is cut to shape and has strips of cloth (or listings) sewn on at intervals. These strips of cloth are tacked to the

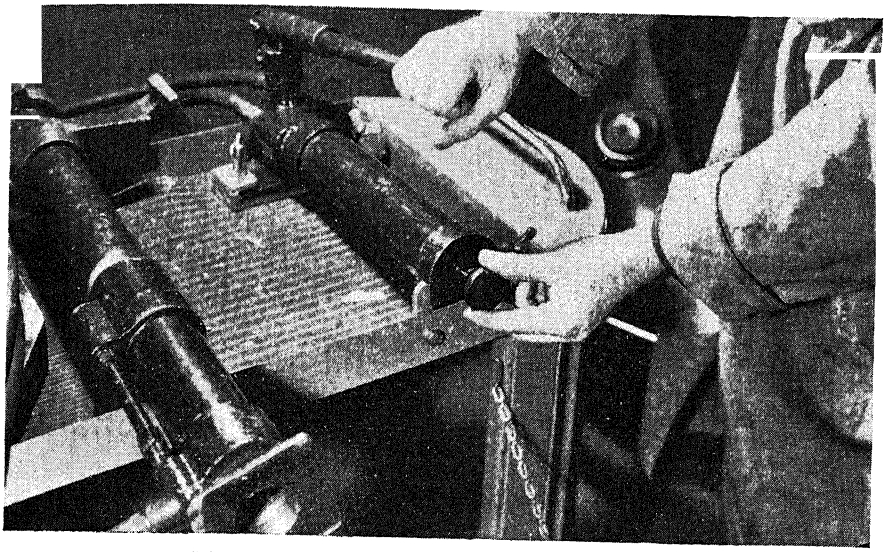


Fig. 13.—HYDRAULIC JACK CONTROL EQUIPMENT
Turning the button which determines the push or pull action of the hydraulic remote control jack illustrated in Figs. 11 and 12. (*By courtesy of Equipments, Ltd.*)

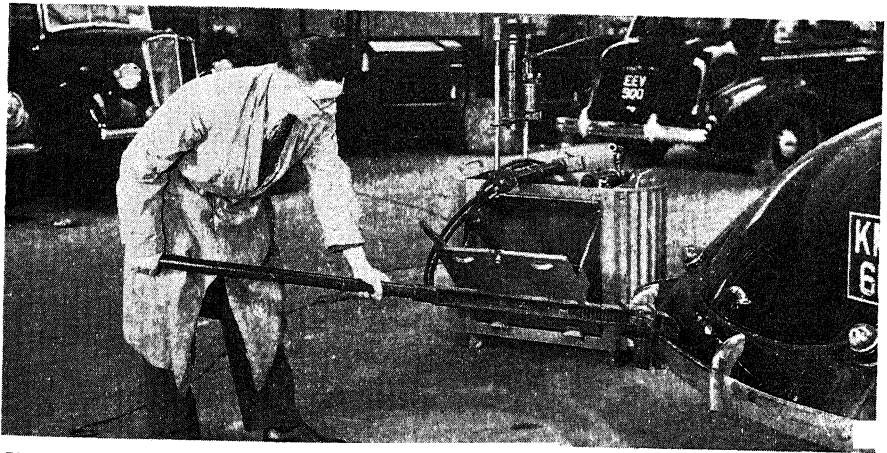


Fig. 14.—LARGE BENDING BAR, INCLUDED IN HYDRAULIC JACK EQUIPMENT, BEING USED ON THE BUMPER OF A CAR
(*By courtesy of Equipments, Ltd.*)

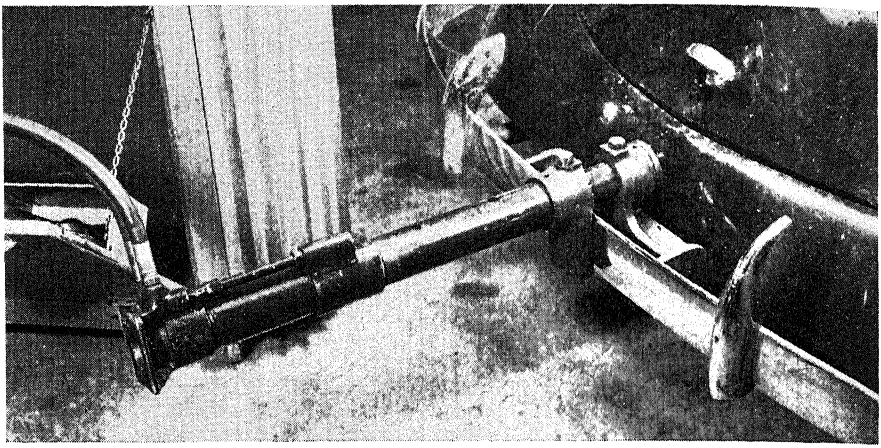


Fig. 15.—USING LARGE HYDRAULIC BENDING CLAMP AND THE CLAMP TO TAKE A BEND OUT OF A BUMPER WITHOUT REMOVING FROM THE CAR

(*By courtesy of Equipments, Ltd.*)

roof cross-members and thus suspend the headcloth in position. The front, rear, and side edges are tacked to trimming strips attached to the upper part of the body.

Rear-seat Squab

The rear-seat squab is made up on a steel-spring frame and is retained in position by two clips which engage the angle strip which forms the rear belt ledge.

To remove the squab it is necessary to take out the bolts in the bottom retainers and draw the bottom of the squab forward, applying at the same time pressure on the top of the squab so that the retainer clips become disengaged, enabling the squab to be lifted clear.

Later bodies are fitted with squabs having tabs at the top, which should be unclipped. If the hinge bolts are removed from the wheel arch, the squab can then be lifted out.

The Front Seats

Earlier models are removed from the body by raising the locking device for the seat position adjustment and sliding the seat rearwards.

On later models the seats can be removed by unscrewing one screw from the rear end of each seat runner.

The Roof Assembly

Both sliding and fixed head roofs of the earlier type can be removed from the body as a complete unit if the windscreen header, side header, quarter panel moulding, upper rear-quarter trim panel, and upper rear trim panel are first removed.

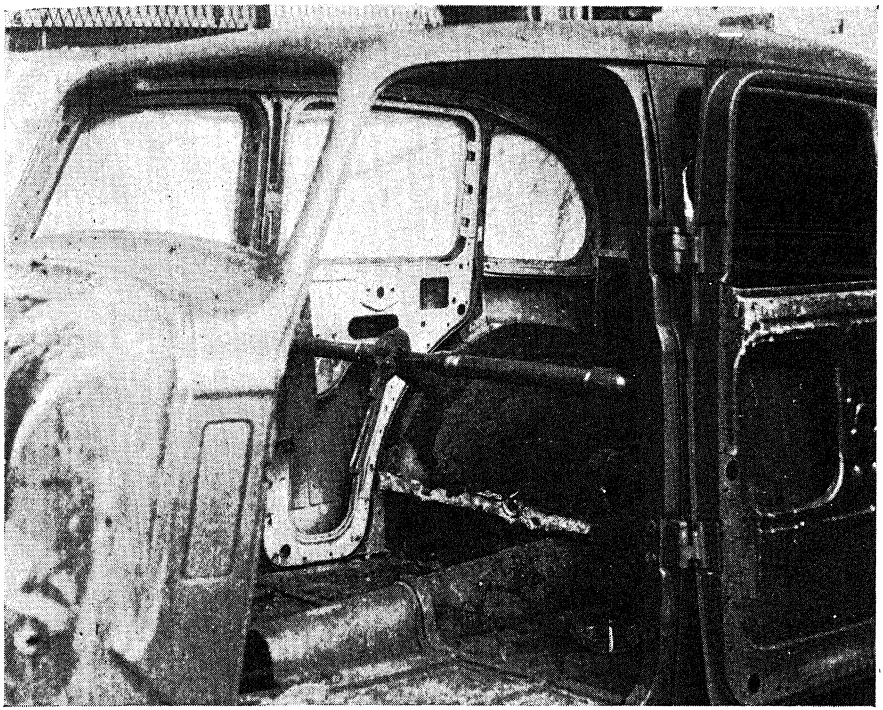


Fig. 16.—BODY JACK IN USE TO FORCE OUT A CENTRE PILLAR WHICH HAS BEEN BENT

To avoid bending the undamaged pillar, a stiffening bar should be inserted between the pillar and the foot of the jack.

The tacks holding the headcloth to the roof sides and front and rear edges should then be withdrawn, permitting the headcloth to hang from the roof centre so that it may be lifted with the roof unit after the fixing screws attaching it to the roof opening flange have been withdrawn.

The roof assembly on later models is removed in the same way except that it is not necessary to disturb the rear and quarter upper trimming.

Removing Door Glasses

To remove the door glasses on the earlier models it is first necessary to remove the garnish rail, trim panel, and unscrew the four setscrews which attach the window-regulating mechanism to the inner door panel. This will enable the regulator unit to be disconnected from the glass cross-channel.

The glass should now be lifted to approximately the half-open position and then withdrawn upwards and inwards towards the inside of the door. This will cause the glass to leave the channels.

Later models employ felt-lined rigid metal channels held in place by

drive screws at their top and centre, and have their bottom end equipped with a metal tab which hooks under the support for the glass run.

To remove the glass it is first necessary to remove the drive screws and slide the channels downwards sufficiently to release the bottom fixing. The glass should then be run up almost to the top of the door, so that the end of the regulator arm can be removed from the slot in the bottom glass channel. The glass and channels can then be raised upwards and inwards bodily until clear of the door.

Removing No-draught Ventilators

The no-draught ventilators are fixed to pivot brackets attached to the door moulding.

To remove the ventilator on the earlier models it is necessary to withdraw the six drive screws attaching the moulding to the door. The ventilator can then be removed from the moulding by undoing the thumb-nut from the quadrant assembly and removing the lower pivot bracket by taking out the two setscrews which hold this component to the angle support. If the ventilator is then slid inwards and downwards, it will be freed from the top bracket. In a later type the ventilator is fixed by three screws and the centre channel, and it can be withdrawn after removing the window moulding and the three screws.

Yet another type of ventilator in use is that fitted with a regulator, and to remove this it is first necessary to remove the window moulding, door trim panel, regulator handle, and recess pad. The four screws which hold the ventilator-regulator mechanism should then be loosened and the three screws removed from the ventilator frame.

This will enable you to pull the ventilator towards the inside of the body at the top and to remove it in an upward direction.

The regulator mechanism can now be removed if necessary by taking out the four screws which were previously only loosened.

Rear Window and Rear Quarter Windows

To remove these windows it is necessary to withdraw the rubber moulding surrounding the glass, which is held in place by an adhesive composition. When replacing the glass, fit the rubber moulding round the edge, with the joint at the top of the glass, and hold it in position by tying a piece of thin cord round the edge, leaving the loose ends on the outside of the glass. Treat the edge with "Bostick" or similar composition and place glass in position from inside the body. Getting an assistant to hold the glass in position on the inside, pull the string from around the glass on the outside of the car. This will bring the edge of the rubber moulding with it, which should now lie flat on the surface of the rear panel.

Removing Centre Channel from Front Doors

If it is necessary to remove the front door centre channel, this can be done without difficulty by removing the door-window moulding, unscrew-

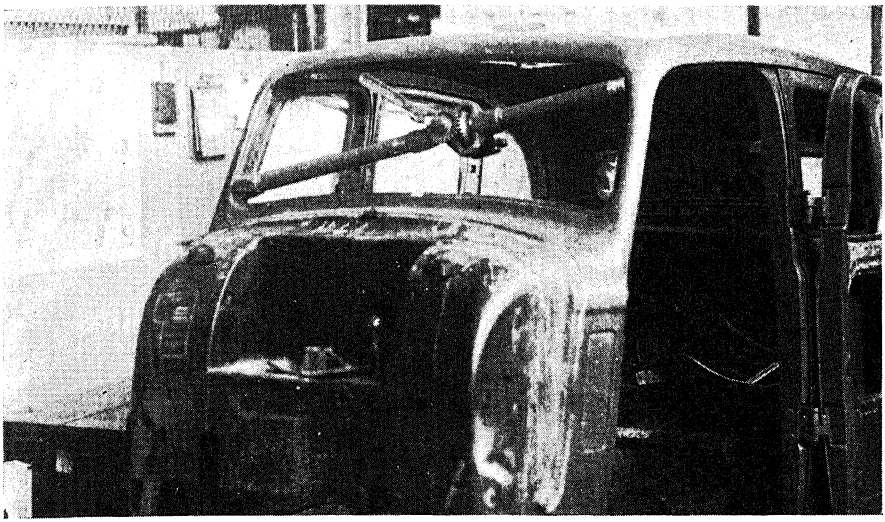


Fig. 17.—SQUARING UP WINDSCREEN OPENING, USING BODY JACK

ing the top screw and three lower screws from the channel, and lifting it out through the window opening.

Squaring up the Body

All parts that are found to have been displaced should be forced back into their correct location with the help of the body jack.

For instance, in the case of a distorted door opening the body jack should be inserted diagonally between the two corners of the door pillars on the diagonal which is too short and the jack expanded until the door frame has been pushed back into its correct shape.

Similarly, a body which has been pushed out of square sideways should be rectified by using the body jack diagonally between the sill and the top rail on the short diagonal.

All portions of the body should be carefully squared up in this way before any attempt is made to remove damaged portions for replacement.

When the body has been squared up as accurately as possible, individual damaged panels can then be pushed out again, employing the body jack for the purpose, together with a suitable dolly.

Straightening damaged portions of the body is often facilitated by heating the metal in the region of the bend and pounding it with the wooden mallet.

It is well to remember, however, that the metal of the body is very thin and that application of the body jack can cause local buckling at the points where it is applied unless the parts are suitably protected by steel bars clamped to the components, or unless suitably shaped dollies

are used on the ends of the jacks. If protecting steel bars are used, the pressure from the jack should always be applied to the steel bars and not to the body material itself.

The Replacement of Parts

Experience with steel bodies will soon show that it is very often possible to recondition parts which look hopelessly damaged, and it is to the repairer's advantage to do so whenever possible, as this is cheaper than replacing the component, and the saving in money will earn the goodwill of the customer.

Whenever possible straighten the parts and weld in preference to replacing.

Local Repairs

Having squared up the body to your satisfaction, it should be carefully examined for local blemishes, and for this purpose the palm of the hand should be passed over the surface, when any irregularity can easily be felt. When doing this, always wear cotton gloves, as this keeps the surface of the metal free from grease, prevents possible damage to the palm of your hand, and assists the detection of blemishes.

If a high degree of accuracy is required, a sheet of abrasive cloth may be used instead of a cotton glove.

Hammering

When using the hammer, it is important that only light blows be used and that care is taken that the blows fall squarely and solidly upon the face of the dolly block or planishing head.

Large Dents

A sandbag will be found most useful for removing large dents, particularly on a painted unit. A bag of oval shape, approximately 8 in. by 6 in. and some 4 in. thick, is a useful size.

When a large buckle or dent takes place, the metal is somewhat stretched in the process, and to remove the dent it is necessary to shrink it back to its normal contour.

This is achieved by heating the damaged portion to a cherry red by a blow-lamp or blow-pipe, and, holding the dolly block underneath, hammering the heated part with the wooden mallet until the metal is cool. This process should be repeated until the dent is completely eradicated.

Small Dents

Small dents and depressions should be removed by the use of a handblock and a paddle made from a heavy milling file—with the teeth still intact.

The dolly should be held in contact with the highest point of the dent and the paddle applied to the opposite side, using light blows until the dent is removed.

Some parts of the panelling are masked on one side by an inner component or panel, and in such cases it is not possible to use the dolly block and paddle. The correct treatment here is to punch a hole with the drift pin through the inside panel, forcing out the depression, or using the lifter for raising the dent.

Small dents on a finished body may sometimes be driven out by the use of a sharp-pointed scribe awl driven through the trimming.

The removal of dents from wings and panels by hot metal. Shrinkage is dealt with on pages 26 to 38 of this volume.

Posts

Door frames or posts that have become dented present another difficulty, since it is by no means an easy matter to obtain access to the inside. The best method of dealing with the situation is to weld a piece of welding wire to the centre of the low spot, form the outer end of the wire into a handle, and then heat the metal round the wire to a cherry red. A steady pull can then be applied to the handle formed on the wire and the dent pulled out to match up with the surrounding metal of the post.

Thin Spots

Where the metal has become thin, through the original working, or the subsequent damage, repair by the methods just described may not be practicable, and recourse will have to be made to patching.

It should here be noted that wrinkles or ridges should not be removed by the process of filing, as this greatly weakens the body structure through thinning of the already thin metal. Any such blemishes should be shrunk by heating to cherry red and hammering with the wooden mallet.

Patching

Where the nature of the damage is such that straightening is impracticable, the part may still be repaired by the insertion of a patch.

It is first of all necessary to remove the damaged portion of the unit by cutting it out with a cold chisel or hacksaw and cleaning up the edges, with a file, so that they are smooth and symmetrical.

Now cut a patch from a piece of sheet steel of the same gauge, and shape the patch roughly to the contour of the component to be patched. Fit this patch into the opening prepared and trim its outer edge so that there is a clearance all round it equal to the gauge of the metal.

You should now tack the patch in position on the unit and finally shape it to conform as closely as possible to the contour of the surrounding metal.

Place plenty of wet asbestos sheet round the weld and weld all the edges together, continuing to shape the patch to the correct contour with dolly and bumping hammer.

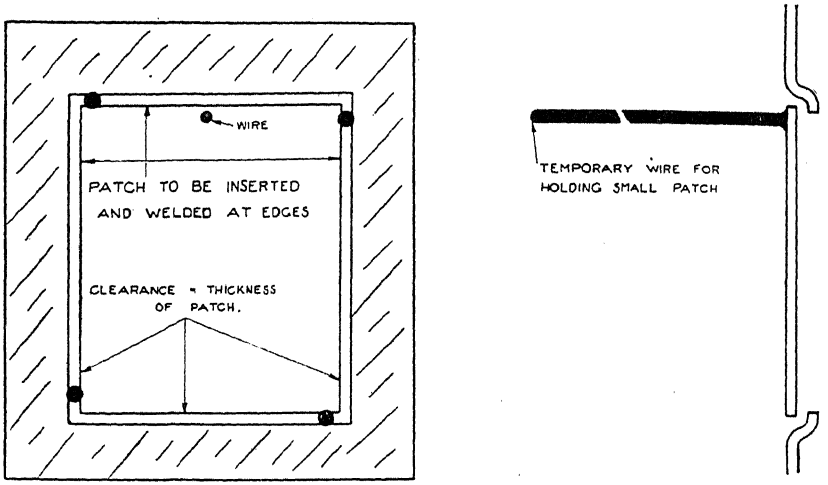


Fig. 18.—PATCHING

Small patches which are difficult to hold in position may be dealt with quite easily by temporarily welding a length of welding wire to act as a handle.

When correctly shaped, remove excess weld on face side and straighten up if necessary with dolly block and bumping hammer.

Sometimes a patch is difficult to hold in position owing to its size or location and the heat of the welding torch. The difficulty may be overcome in such cases by welding a short length of welding wire to the patch and using this as a temporary handle with which to hold the patch in position while tacking. The wire can afterwards be cut off and the spot cleaned up.

Forming Patches

It is often necessary to raise or bump out the patch to shape from the flat sheet so that it matches up with the body contour.

For this purpose a ball-pein hammer and a wooden or lead raising block with several spherical depressions of varying size should be used.

When raising work on the block described, the pein end of the hammer is used, and it is of great importance to remember that the forming should start at the outer edge and gradually work towards the centre of the area to be dealt with.

An error which is often made is to hammer too hard while raising the centre, and thus produce a curve of greater depth than is required. This

stretches the metal, which has then to be shrunk again in order to rectify matters, and as this is not an easy matter the operator is advised to be very careful with the use of the hammer when forming.

Replacing Components

In cases where a component, such as a door pillar, has been buckled beyond repair, the old post can be sawn off about 3 in. from each end, and a new one inserted by welding after it has been cut to the right length.

In extreme cases it may be necessary to insert an extensive new area of the body structure, and this can be carried out quite successfully by obtaining a replacement panel from the makers and cutting away the defective portion of the body.

Quite extensive repairs of this nature can be carried out on all-steel bodies, and it is not necessary to remove the body from the chassis for this on the latest models, although it is of course necessary to remove all interior trimming and hardware in the region of the repair.

A few examples of extensively damaged bodies are shown in the illustrations, together with indications as to where the body should be cut for replacement purposes. It will be seen that each repair will call for a different treatment, but the general scheme employed will be gathered from the illustrations.

Breaking Welds

In the repair of damaged bodies it often becomes necessary to break the original weld in order to remove the damaged part.

The procedure to use when parting the weld differs, of course, from the welding process employed in making the weld.

To break a spot weld the best method is to drill a hole of approximately $\frac{3}{16}$-in. diameter through the centre of the weld and to force the panels apart by driving a cold chisel between them. When the new panel is being welded in position the new weld—which will be made by the oxy-acetylene process—can be made through the hole which was made when parting the spot weld, thus filling it again.

Where the original weld was made by the oxy-acetylene process the weld should be cut with a cold chisel and hammer. If the weld was filled over with solder, the solder should be melted and wiped away.

Some of the welds on all-steel bodies—notably that between the side panels and rear panel—are made by butt welding the edges together by the electrical-resistance welding process. Such joints can usually be parted by means of a cold chisel and hammer, directing the blows against the panel which is to be scrapped.

If difficulty is encountered in parting such a weld in this manner, the joint can be heated up with an oxy-acetylene torch so that the fused edges of the panels are softened, thus assisting in the breaking of the weld.



Fig. 19.—THIS BODY HAS A BADLY CRUSHED PANEL SCUTTLE AND "A" POST

In such a case, the scuttle and post should be cut away where indicated, and fresh panels welded in. Do not forget first to square up the body with the body jack.



Fig. 20.—THIS BODY HAS A BADLY CRUSHED "A," "B," AND "C" POST

Here it is advisable to cut away the damaged portion, as shown by the dotted lines, after carefully squaring up the body with the body jack.

Scuttle Repairs

On bodies built prior to 1936 it is necessary to remove the bolts holding the body on to the chassis in order that it may be lifted some 6 in. to give access to the bottom weld if attention is required at this point.

To separate the scuttle panel from the side panels it is first necessary to break through the oxy-acetylene weld at the front end of the roof side panels where they join the top screen panel.

The spot welds on the face of the " A " post half-way down the screen pillar and just above and below the door lock striker where the side panel half laps on the " A " post should be drilled through.

Working from the inside, a cold chisel should be driven between the side panel and the scuttle half of the " A " post to part the spot welds.

With a hacksaw cut through the lower part of the body, forward of the door opening, as closely as possible to the oxy-acetylene weld, which can easily be located from the inside.

This will release the scuttle unit, which can now be withdrawn.

Rebolt the sides of the body in position and also bolt the new scuttle assembly in position on the chassis, thus using the chassis as an assembly jig.

Now reweld the roof side panels to the new scuttle. Clamp the two halves of the " A " post together and weld together through the holes drilled for parting the spot welds.

Release the body from the chassis and raise till scuttle-panel lower edge is clear of chassis. Reweld the scuttle panel to the forward end of the body sill.

Clean off all welds and bump them down where necessary for filling with solder, as will be described later.

Removing Scuttle Pressing on later Models

On later models the scuttle panel is flash welded to the side panels, and it is necessary to break through the welds between scuttle top panel and the scuttle side panels, which are formed in one piece with the body side panels.

It is also necessary to break through the welds between the scuttle top panel and the windscreen bottom flange, and also through the welds down the front pillar and dashpan side flanges.

Further welds which must be broken through are located between the front pillar bottom bracket and the side of the dashpan ; between the front pillar and its reinforcements to the scuttle top panel and " A " post lower reinforcement.

The reinforcement for the windscreen top panel should now be removed by breaking through the welds in the windscreen top panel where it joins on to the forward ends of the body side panels, and by using a hacksaw cut through the joint seam, which can easily be seen from the inside.

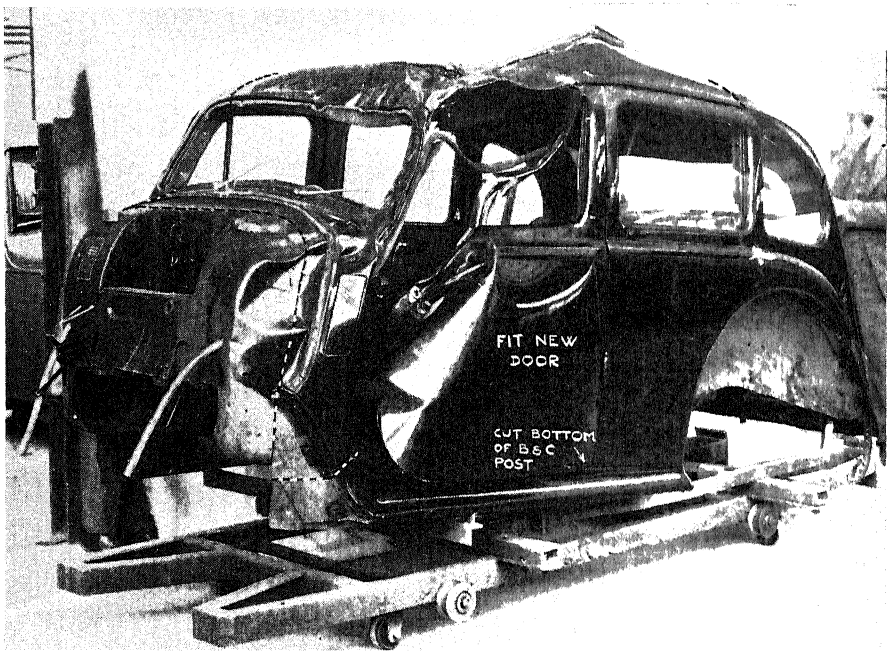


Fig. 21.—HOW TO REPAIR DAMAGE OF THIS NATURE
Cut away the upper and lower windscreen panels and the forward end of the side panel at the points indicated. New panels should then be welded in and a new front door fitted.

The joint seam between the scuttle top panel and the scuttle side panels can be sawn in a similar way.

A temporary windscreen frame is necessary to locate correctly the components on reassembly.

The new scuttle should be located in position, butting up against the side panels, and the extreme ends of the joints should be tacked in position. The whole length of the joint should now be tacked at intervals of 2 in., making sure that it is correctly located, and finally welded over its entire length.

The dashpan can now be replaced and welded round the hood ledge, front pillar, and windscreen bottom rail through the holes made when breaking the old welds.

Weld the top screen panel reinforcement along the windscreen to the fixed support, and weld the front pillar lower reinforcement.

Finally weld the bottom bracket to the dashpan and the dashpan bottom flange to the side sill.

Replacing Rear Panels

Two types of rear panel joints have been used, the earlier type of joint being butt welded while the later type is flash welded. Which type

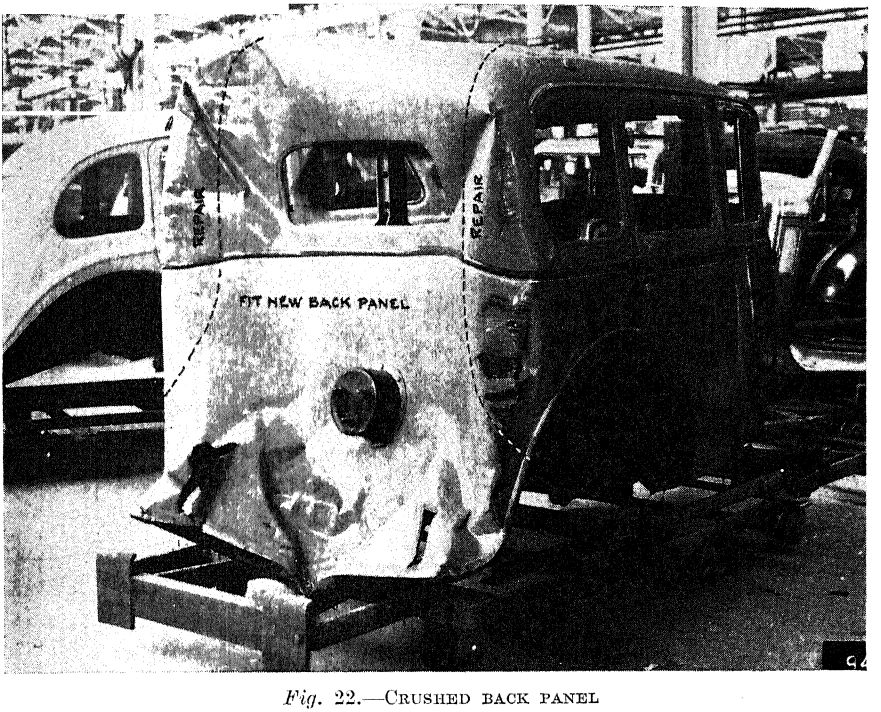


Fig. 22.—CRUSHED BACK PANEL

With a crushed back panel of the type shown, the panel should be cut away, the damaged portions of the side panels repaired, and a new rear panel fitted.

of welding is used on any particular body is easily seen as soon as the interior trimming is removed, as the continuous molten seam of the flash welding is unmistakable.

To remove the back panel it is first necessary to withdraw the body holding-down bolts and raise the body approximately 6 in. above the chassis.

The usual $\frac{3}{16}$-in. diameter holes should now be drilled through all the spot welds on the components concerned, and, using a cold chisel, the seat pan should be removed.

The spot welds holding the roof-opening corner brace to the rear panel should now be broken, but do not break the welds which locate the brace to the side panels.

Using a hacksaw or oxygen torch, cut away the back panel approximately 1 in. inside the original point so as to leave that amount of extra metal on the body side panels.

Locate the new rear panel in position, letting it lap over the 1-in. wide strips left on the side panel. The new panel can be located approximately by lining up its edges with those of the original butt welding.

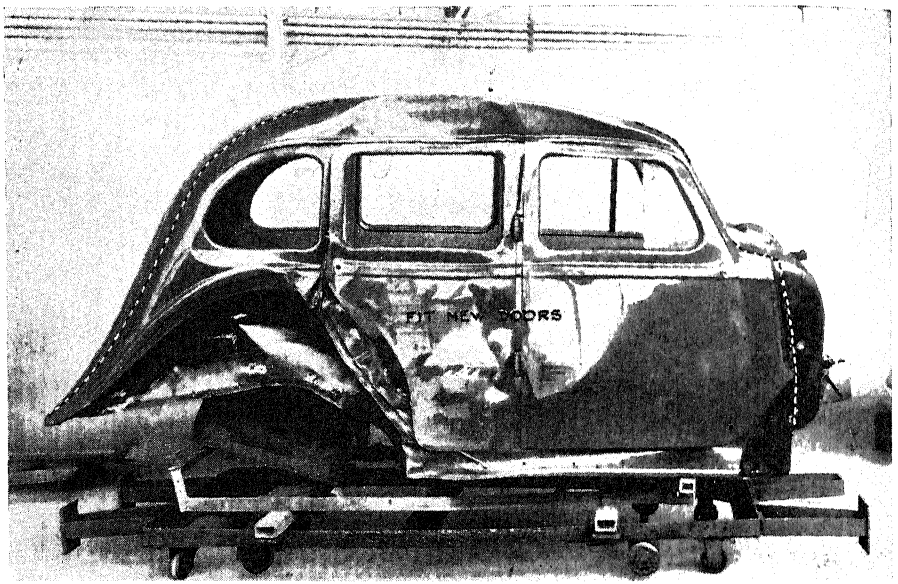


Fig. 23.—IN A SMASH OF THIS NATURE, IT IS ADVISABLE TO CUT AWAY THE SIDE PANEL COMPLETELY AND TO WELD IN A NEW UNIT
The location of the cuts is clearly indicated by the dotted lines.

When properly located, weld the bottom ends of the panel with the oxy-acetylene torch and tack the upper ends of the panel in position on the side panels. Lower the body on to the chassis, bolt into position, and check up alignment of new panel. If correct, weld the complete length of the overlapping panel, clean off, and fill with solder as necessary.

Reweld the roof-opening corner bracket in position through the drilled holes and replace the seat pan, also welding in position.

The roof-opening corner braces should be released from the rear panel in the same way. Welds will be found between the rear quarter-light* frame and the rear-light upper and lower rails. These welds should be broken through.

The welds of the luggage-shelf side supports, where they are attached to the wheel arch, should also be broken, together with the undershield reinforcement where it is welded to the wheel arch.

Using a hacksaw or cold chisel, the rear panel can now be cut out as close as possible to the original joint, but on the " side-panel " side of the joint, leaving the old joint on the rear panel.

Obtain a new rear panel and hammer a ledge, metal-thickness deep, all down its edge, so that when placed in position the faces of the side panels and rear panel lie perfectly flush, taking care to see that the lip

* Window openings are called " lights " in the trade.

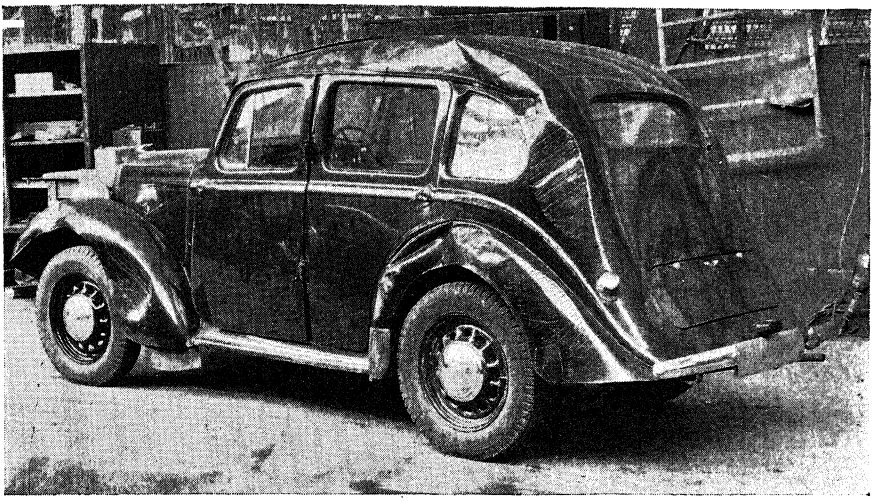


Fig. 24.—A BODY WITH A BADLY DAMAGED SIDE

A completely new side can be welded in after squaring up the body and cutting away the damaged parts, as will be seen from the three following illustrations.



Fig. 25.—REPAIR OF THE BODY SHOWN IN FIG. 24

Here the damaged parts have been cut away and the body is now ready for the reception of the new side assembly, as shown in the next figure.

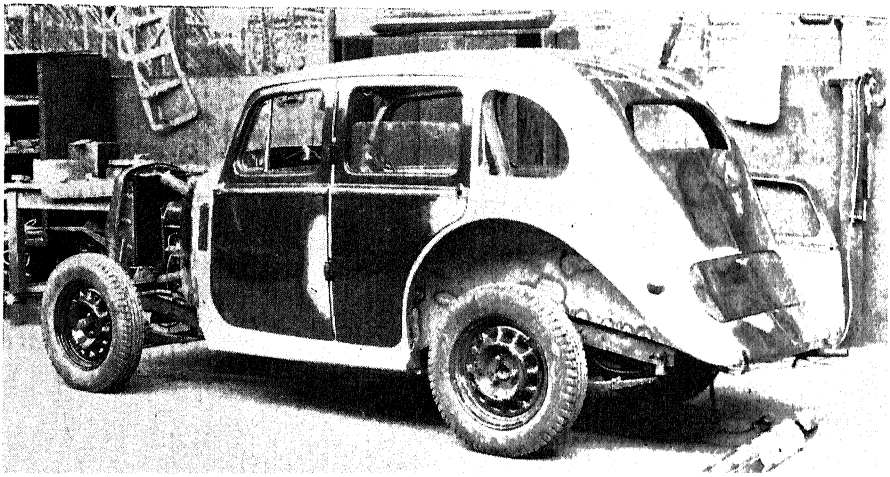


Fig. 26.—THE ABOVE PICTURE SHOWS THE NEW SIDE ASSEMBLY AFTER IT HAS BEEN WELDED INTO POSITION

All the joints have now been filled with solder, as described on pages 246–248.

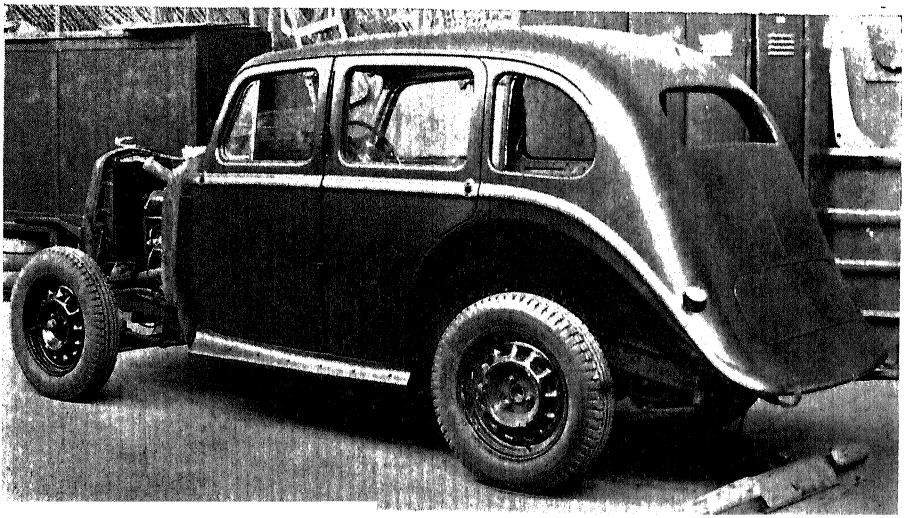


Fig. 27.—THE FINISHED REPAIR

It will be noted that the body has received its first coat of priming.

of the ledge is in alignment with the edge of the corresponding side panel.

You may now proceed to weld the joint, straightening, bumping, and filling with solder as required.

Replacing Body Side Panels

The body side panels are "one-piece" pressings, and when assembled to the scuttle assembly and back panel form the complete body.

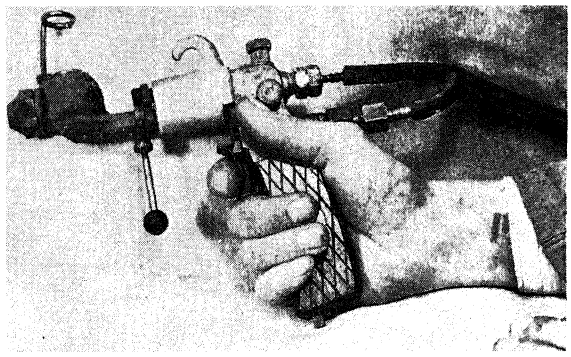


Fig. 28.—ACE SOLDER SPRAY GUN FOR FILLING IN DENTS IN WINGS AND PANELS

The use of this tool is illustrated in Figs. 29–32. It is connected to acetylene line at 10 lb. pressure and compressed air line at 40 lb. pressure. Instead of compressed air, oxygen at 25 lb. may be used if more convenient. (*By courtesy of Equipments, Ltd.*)

The method of parting the forward end from the scuttle assembly has already been fully dealt with under "Replacing Scuttle," and the parting of the rear end under "Replacing Rear Panel," so that it is unnecessary to repeat these instructions.

It is, however, important to bear in mind that slight differences in procedure are necessary in view of the fact that the "good" panels now to be saved were the "bad" ones in the previous operations.

For this reason, instead of completely removing the seat pan in the butt-welded bodies, it is necessary only to break the welds holding the pan to the side which is to be removed; to break the roof-opening corner brace from its attachment to the side panels, and to cut the panel on the "side-panel" side of the butt weld. In this case, too, the chassis may with advantage be used as an assembly jig to correctly locate the components before welding.

In the case of bodies which are flash welded together it is necessary only to break through the welds at the forward end on the side which is to be removed; to remember to break the welds of the roof-opening corner brace at the end where they are attached to the side panels, and to break through the seam joint of the rear panel on the rear-panel side, leaving the welded portion on the side panel.

The Finishing of Welds

In order to smooth over the irregularities of welds, torch soldering is recommended, as this obviates weakening the weld by excessive cleaning, which would seriously reduce the thickness of the metal.

The solders recommended are those known as "tinman's" solder,

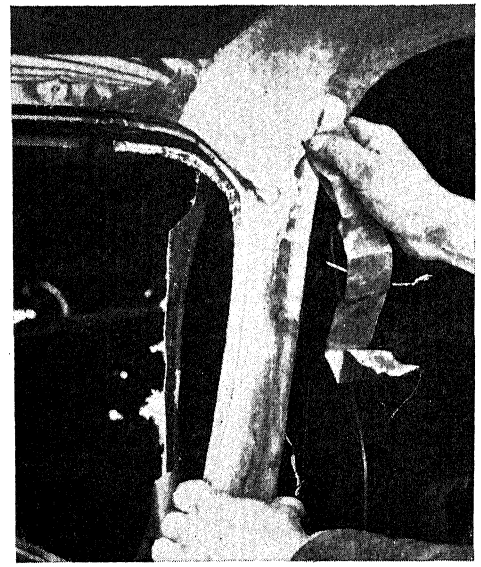


Fig. 29.—FILLING IN DENTS—FIRST OPERATION
Cleaning dent to be filled in prior to tinning.

which is an alloy of 60 per cent. lead and 40 per cent. tin, and "plumber's" solder, which contains 70 per cent. lead and 30 per cent. tin. Tinman's solder, because of its greater proportion of tin, alloys more readily with the surface of the sheet steel, but plumber's solder remains in a plastic condition over a greater range of temperature—from 509° F. down to 358° F.—within which range it can be moulded to any desired shape.

Where it is desired to build up a contour with solder, the sheet steel must first of all be cleaned thoroughly. Rust, scale, welding oxide must all be removed by means of emery cloth, or a polishing head if available.

The clean metal surface is now gently heated with a blow-lamp and a paste-type soldering flux applied with a brush. The tinman's solder is then applied to the surface and rubbed with a wad of hemp over the surface of the steel, so that it becomes coated—or tinned—with solder. This is the foundation for the plumber's solder which will be used subsequently to build up the contour, and the success of the final result depends upon this "tinning" operation.

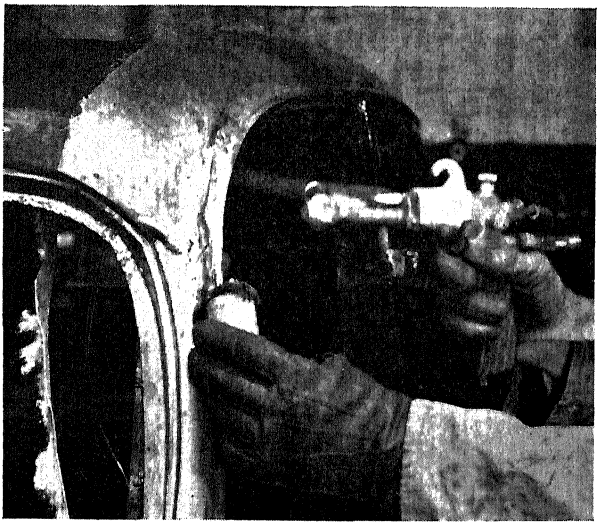


Fig. 30.—FILLING IN DENTS—SECOND OPERATION
A film of tinner from a tube is spread over the dent. The flame from the ace solder gun is then directed on the tinner, causing it to flow. When cold, the excess tinner is wiped off with steel wool, and the job is ready for spray soldering.

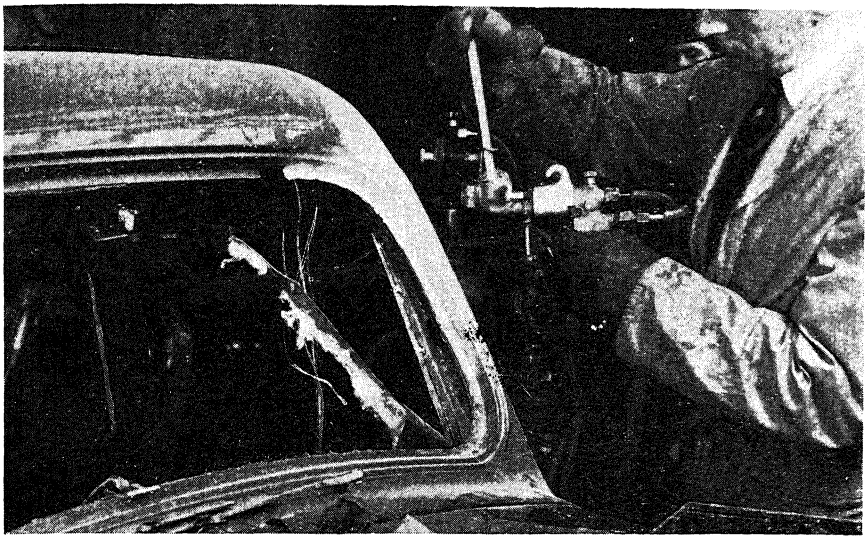


Fig. 31.—FILLING IN DENTS—THIRD OPERATION

Spraying the solder, which is in stick form, mounted at the head of the gun.

Filling with Solder

When the surface has been thoroughly "tinned" a little more flux is applied and the part again gently heated with the blow-lamp. The plumber's solder is now melted on to the surface and maintained in a plastic condition by careful application of the blow-lamp whilst it is moulded to the desired shape

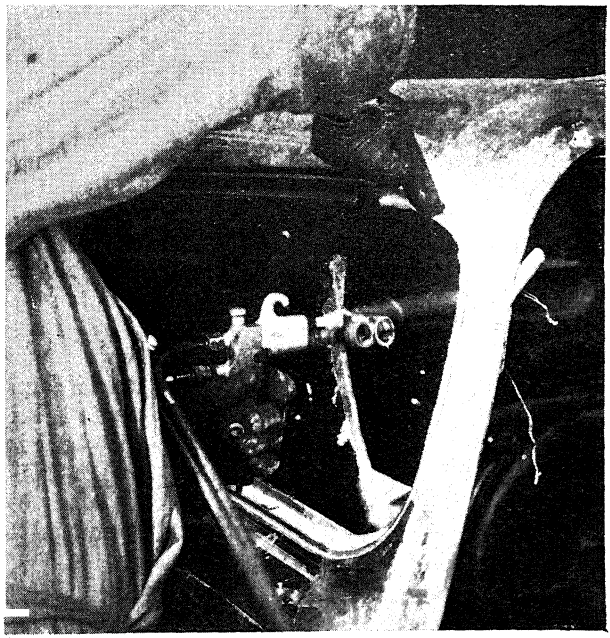


Fig. 32.—FILLING IN DENTS—FOURTH OPERATION

After the dent has been sprayed with solder, the surface of the solder is moulded as required with a paddling block and a special lubricant which does not carbonise on the work, while the solder filling is heated with the torch. The surface may be finished with a file and emery paper.

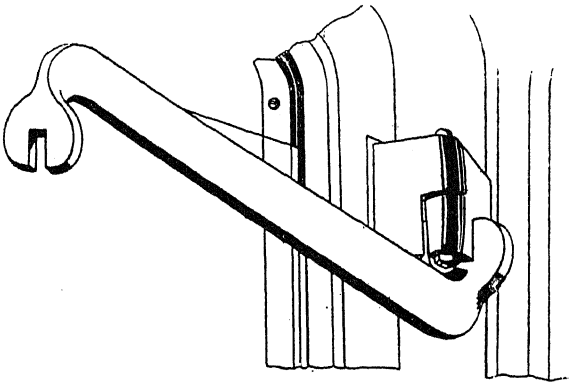


Fig. 33.—ADJUSTING DOORS

Where the doors are both hung on the centre pillar, a setting tool of the type shown should be used to set the doors away from the pillar.

with a paddle made of hardwood.

Frequent immersion of the paddle in palm oil during the operation assists in the manipulation of the solder, but if palm oil is not available boiled linseed oil, lard oil, mutton tallow, or machine oil may be used.

The method of finishing welds and filling in dents in wings and panels, using a solder spray gun, is shown in Figs. 28–32.

Door and Window-regulator Handles

On the later types of steel bodies the inside door handles are provided with a pin passing through the crank and handle, which is prevented from coming out by the escutcheon plate, which is in turn held forward by a spring. To remove the handle it is necessary to push back the escutcheon plate to a point where the pin is exposed and push out the pin with a small punch.

Earlier models have the handle fixed in position by a magnetised key engaging in a slot in the handle and the spindle. This key is held in position by the spring-loaded escutcheon plate in a similar manner to the later model, but in some instances a rubber pad replaces the spring.

Other models are fixed in position by a spring-loaded catch which engages a slot in the shank of the handle, and which can be released by inserting a pin punch in the small hole provided in the boss of the handle and holding aside the spring while the handle is being withdrawn.

In yet another model the door handle is held in position by a spring-loaded disc incorporated in the escutcheon plate which engages across the corners of the remote-control spindle. To remove this handle it is necessary to push round the tag formed on the underside of the handle, pulling the handle towards you at the same time.

Door Striking Plates and Dovetails

The striking plate is held in place by four screws which screw into holes tapped in a steel block held in a cage inside the door pillar. Removal of the four screws releases the striker plate.

The dovetails are fitted in a similar manner, but are adjustable horizontally rather than vertically.

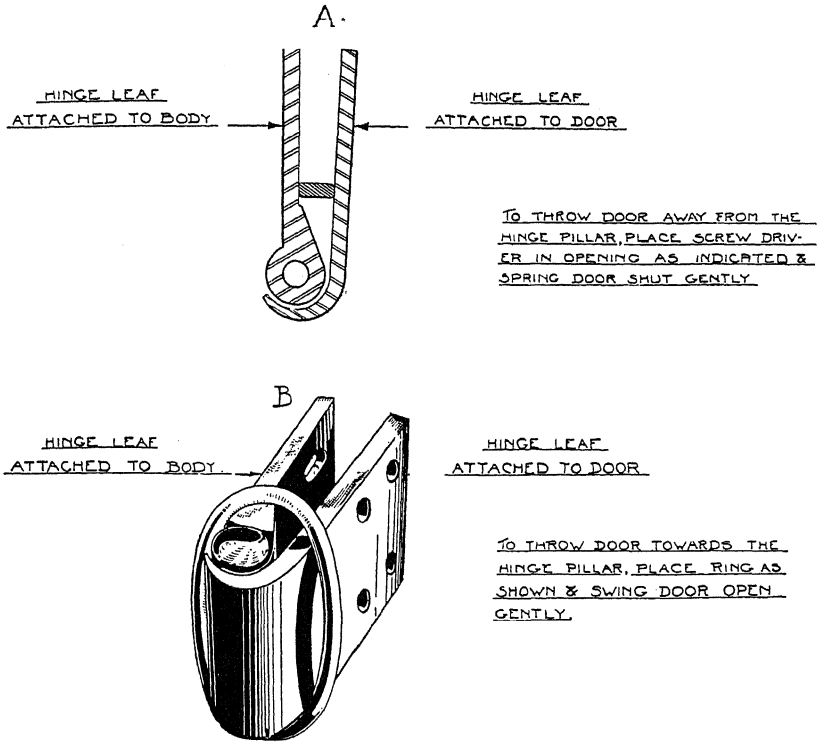


Fig. 34.—THE METHODS TO EMPLOY FOR SETTING HINGES

Door Checks

To remove the check on recent models, remove the bolt in the check link from the sill and swing the link round to the door panel, which will enable it to slip out of its slot.

On the earlier models it is first necessary to remove the body trimming to give access to the two screws holding the check in position. When these screws are removed, push the check back through the slot in the post and that in the door and remove the door trimming panel to retrieve the check from inside the door.

Adjusting Doors

When a body has been repaired it is usual to expect that a certain amount of adjustment has to be undertaken to ensure smooth shutting.

The position of the door in the door opening is adjusted by bending the blades of the hinges in the appropriate direction.

To set the door away from the hinge pillar the door should be opened, a screwdriver inserted between the hinge blades, and the door closed until the correct amount of set is attained.

To set the door more closely towards the hinge pillar a chain link of appropriate size should be slipped over the hinge and the door sprung open slightly.

Another method of setting the hinge is to use a twisting wrench, but this should only be used to set the door away from the hinge pillar, the chain link being used for setting in the other direction.

Some models have both the front and rear doors hung from the centre pillar, and these have to be dealt with differently.

To set the doors away from the pillar the screwdriver is inserted between the hinge blade attached to the door and that fixed to the pillar, and the door closed as before. To throw the door towards the hinge pillar it is necessary to insert a wedge in the shut pillar, close the door, and give the hinge leaf attached to the door a sharp blow with a caulking tool or drift close up to the door frame.

MONOPIECE CONSTRUCTION

Body and Underframe Repairs on the Morris Ten (Series "M")

In the repair of the Morris Ten (Series "M") car the same general principles and methods are employed as for normal all-steel bodies already described, with only the slight modifications entailed by the special form of construction employed in the production of this car, which has its chassis built as an integral part of the body instead of taking the form of a separate unit as in orthodox practice. Naturally, this scheme of monopiece construction introduces certain differences of repair procedure, which we propose to deal with in this section.

The first essential in the proper repair of the car under consideration is a thorough knowledge of the separate units from which it is constructed, so that the position of the various joints may accurately be located when a repair is called for, and the correct replacement units obtained from the manufacturers.

Reference to the two accompanying Figs. (35 and 36), showing the various component parts of the Morris Ten separated, will enable you to follow the details of the construction and will also indicate which replacement parts to requisition in order to deal with any repair however extensive it may be.

From the illustrations it will be seen that the two members which take the place of the normal chassis side members are built up of two pieces joined at the middle by flash welding. This facilitates repairs to the forward or rear ends, as only one-half of the side members need be

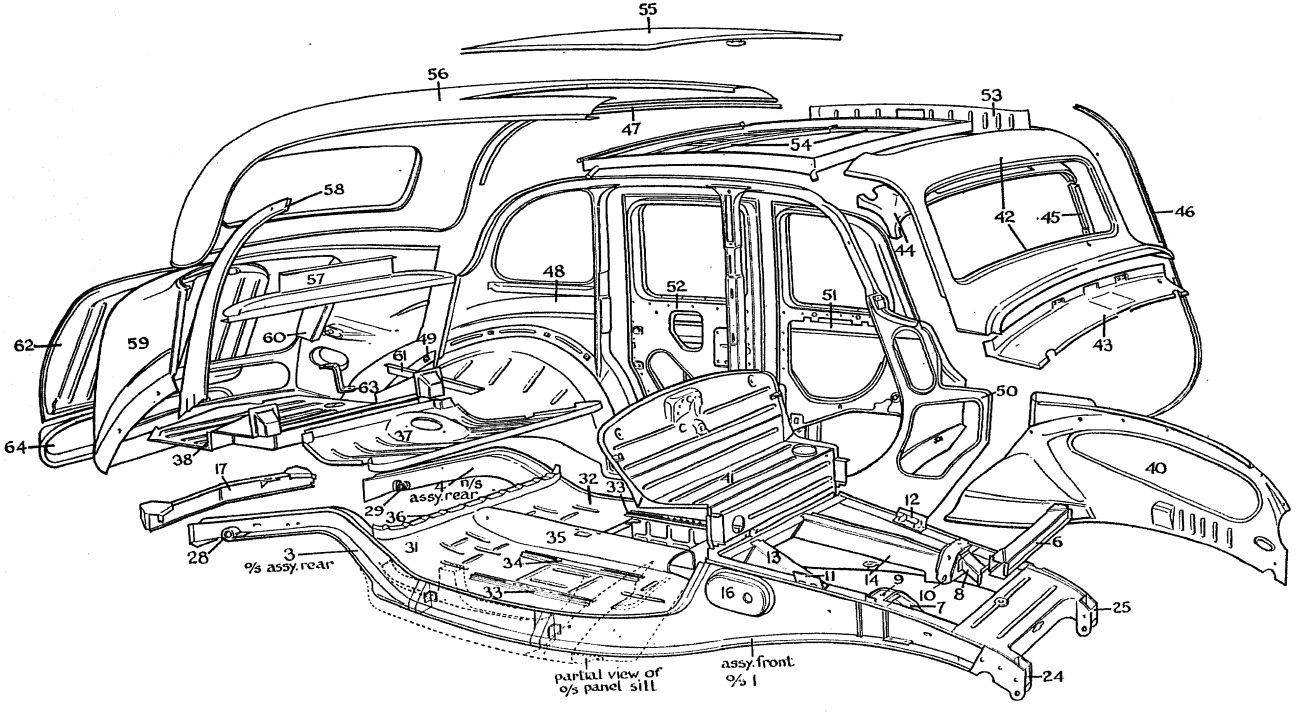


Fig. 35.—THE SEPARATE PANELS FOR THE MONOPIECE CONSTRUCTION OF THE MORRIS TEN (SERIES "M")

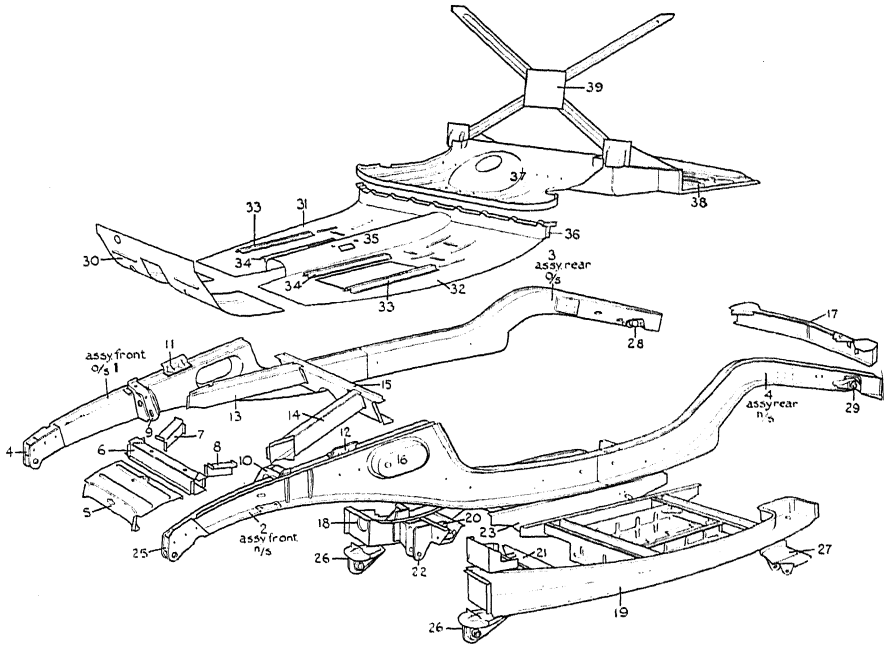


Fig. 36.—COMPONENTS OF UNDERFRAME, MORRIS TEN (SERIES "M")

replaced in the majority of cases when the car has been extensively damaged.

The side members are connected together by a series of cross-members, in a similar way to the normal chassis, and the forward end is stiffened by two diagonal members. It will be noted that the frame side members are assembled with their open sides outwards, and are stiffened over the centre portion by a sub-frame assembly which carries the front and rear spring anchorages at its four corners. This sub-assembly also carries the toolbox and the lower half of the tubular propeller-shaft tunnel. The centre portion of the frame is covered by a sheet-metal tray which functions as the floor and incorporates the upper half of the propeller-shaft tunnel. Forward of this metal tray is a curved pressing which forms the toe-board, while another pressing at the rear forms the rear-seat tray, which is in turn welded to another tray pressing, which serves as the support for the horizontally disposed spare wheel.

The body superstructure consists of side-panel assemblies containing the "A," "B" and "C" and "D" posts, the wheel-arch panel, a portion of the scuttle panel, and the lower shroud reinforcement. This structure is welded to the frame side members and then extended forward by welding the wing valance assemblies in position.

At the rear the side assemblies are joined together by the trunk panel,

LIST OF REPAIR PANELS, MORRIS TEN (SERIES "M")

With "Identity Numbers" as indicated in the "Exploded View" illustrations (Figs. 35 and 36)

Description	*No. Reqd.*	*Part No.*	*Identity No.*
Side-member assembly (front) O/S	1	95068	1
,, ,, ,, (front) N/S	1	95069	2
,, ,, ,, (rear) O/S	1	95070	3
,, ,, ,, (rear) N/S	1	95071	4
Front-splasher assembly	1	84943	5
Front cross-member assembly	1	95072	6
Stiffener (front cross-member to engine bracket) O/S	1	84525	7
,, (front cross-member to engine bracket) N/S	1	84526	8
Front engine-bracket assembly O/S	1	83967	9
,, ,, ,, ,, N/S	1	83968	10
Stiffener (front shock absorber) O/S	1	83985	11
,, (front shock absorber) N/S	1	83985	12
Frame-brace assembly O/S	1	83958	13
,, ,, ,, N/S	1	83959	14
Dash support cross-member assembly	1	95013	15
Spacer (chassis to valance)	2	84538	16
Rear cross-member assembly	1	83964	17
Stiffener assembly (main floor) O/S	1	95073	18
,, ,, (main floor) N/S	1	95074	19
Floor cross-member assembly (front) O/S	1	95075	20
,, ,, ,, ,, (front) N/S	1	95076	21
Clutch pedal-bracket assembly	1	84510	22
Tunnel (lower)	1	84993	23
Front spring front bracket assembly O/S	1	84918	24
,, ,, ,, ,, ,, N/S	1	84919	25
Front spring rear bracket assembly	2	83982	26
Rear spring front bracket assembly O/S	1	83952	—
,, ,, ,, ,, ,, N/S	1	83953	27
Rear spring rear bracket assembly O/S	1	83956	28
,, ,, ,, ,, ,, N/S	1	83957	29
Front floor panel assembly	1	95077	30
Floor side assembly O/S	1	84950	31
,, ,, ,, N/S	1	84951	32
Seat runner (locking)	2	84003	33
,, ,, (plain)	2	84002	34
Tunnel assembly (upper)	1	84949	35
Heel-board assembly	1	84500	36
Lockheed-hose bracket	1	83989	—
Seat-pan assembly	1	84994	37
Spare-wheel floor assembly	1	95078	38
Squab cross-brace assembly	1	105420	39
Front-valance assembly O/S	1	105490	—
,, ,, ,, N/S	1	105491	40
Front wing stay support O/S	1	105402	—
,, ,, ,, ,, N/S	1	105403	—
Dashpan assembly	1	105421	41
Windscreen panel (S.H. Saloon)	1	105339	42
,, ,, (F.H. Saloon)	1	105915	—
Windscreen lower rail	1	105419	43
Windscreen hinge-bracket assembly	1	105480	44
Upper panel shroud assembly (inner) O/S	1	105980	—
,, ,, ,, ,, (inner) N/S	1	105981	45

LIST OF REPAIR PANELS, MORRIS TEN (SERIES "M")—*continued*

Description	*No. Reqd.*	*Part No.*	*Identity No.*
Drip moulding (front) O/S		105142	
,, ,, (front) N/S		105143	46
,, ,, (roof) O/S		105482	—
,, ,, (roof) N/S		105483	47
Side panel O/S		105924	—
,, ,, N/S		105925	48
Wheel-arch filler O/S		105930	—
,, ,, ,, N/S		105931	49
Lower panel shroud assembly O/S		105978	—
,, ,, ,, ,, N/S		105979	50
Front-door assembly O/S		105926	—
,, ,, ,, N/S		105927	51
Rear-door assembly O/S		105928	—
,, ,, ,, N/S		105929	52
Side-header reinforcement O/S		105982	—
,, ,, ,, N/S		105983	53
Sliding-roof channel assembly		105332	54
Sliding-lid assembly		105418	55
Roof panel (S.H. Saloon)		105338	56
,, ,, (F.H. Saloon)		105913	—
Parcel shelf		105130	57
Quarter-light reinforcement O/S		105478	58
,, ,, ,, N/S		105479	—
Trunk-panel assembly		105111	59
Trunk-opening reinforcement		105312	60
Trunk-floor side support O/S		105496	—
,, ,, ,, ,, N/S		105497	61
Trunk-floor rear support		105314	—
Trunk-lid assembly		105932	62
Spare-wheel clip		83954	63
Spare-wheel lid assembly		105101	64

which is spot welded to the rear quarter panels, the joints being hidden by plumber's solder.

At the scuttle the assembly is completed by welding the dashpan in position, and then the windscreen panel, which includes the top panel for the scuttle.

The roof sub-assembly, consisting of the sliding-head channel assembly, is welded to the windscreen assembly at the forward end and to the body side assemblies on each side, the actual roof panel incorporating the rear light being flash welded to the windscreen panel and spot welded to the body side assemblies and trunk panel.

The First Step on Repairing

When undertaking a repair it is first necessary to straighten the bent or distorted portions of the body structure, using the body-straightening

jack and special end pads as indicated in the section dealing with steel-bodywork repair in general.

If your standard end pads do not fit snugly into the contour of the body of the Series "M" Morris Ten, it is advisable to prepare suitable end pads in hardwood in order to avoid the possibility of damage to the good portions of the body.

Remember, also, that it is essential to anchor the foot of the jack against a portion of the body which cannot easily be distorted. For instance, if you want to straighten out a bent door-post do *not* anchor the foot of the jack to the centre of the opposite door-post, but use it diagonally with its foot leaning against the base of the opposite pillar or some similar rigid portion of the structure. The body jack is a powerful tool and must be used with intelligence if the best results are to be obtained.

Remember, also, that this type of construction lends itself to a considerable amount of straightening, and that parts which often look past salvage can frequently be rendered quite serviceable by careful straightening and beating.

Having failed to straighten out the damage successfully, consideration may be given to replacement of the damaged portion, and a careful decision made as to where the damaged part will be cut away.

Whenever possible it is always advisable to stagger the joints where two or more panels are adjacent to each other.

Only whole replacement panels as indicated in the accompanying illustrations are supplied by Morris Motors Limited, so that you may have to order more material than you actually require. When the new panel arrives, carefully cut it to match up with the existing portion of the body, retaining any pieces left over as they may be of use in later repairs undertaken.

Checking Alignment

Owing to the special construction the procedure necessary for checking the alignment of the body either before or after repair is slightly more involved than on the orthodox chassis owing to the presence of the body structure.

A good method is to carefully plot the position of the essential portions of the body on a smooth and level floor.

It is, of course, essential that the chassis should lie perfectly level during this operation, and to ensure this a spirit-level should be placed on the flat surfaces at the front and rear ends of the sub-frame, adjusting the level accordingly. If the axles and wheels are in position the level can be adjusted by a suitable manipulation of the tyre pressures.

The centre line of the sub-frame can be marked out on the floor by the use of a plumb-bob and line, and the position of the spring-anchorage bolt-holes and shackle-bolt holes can then also be plotted on the floor, remembering to use the same side of the lugs in all cases.

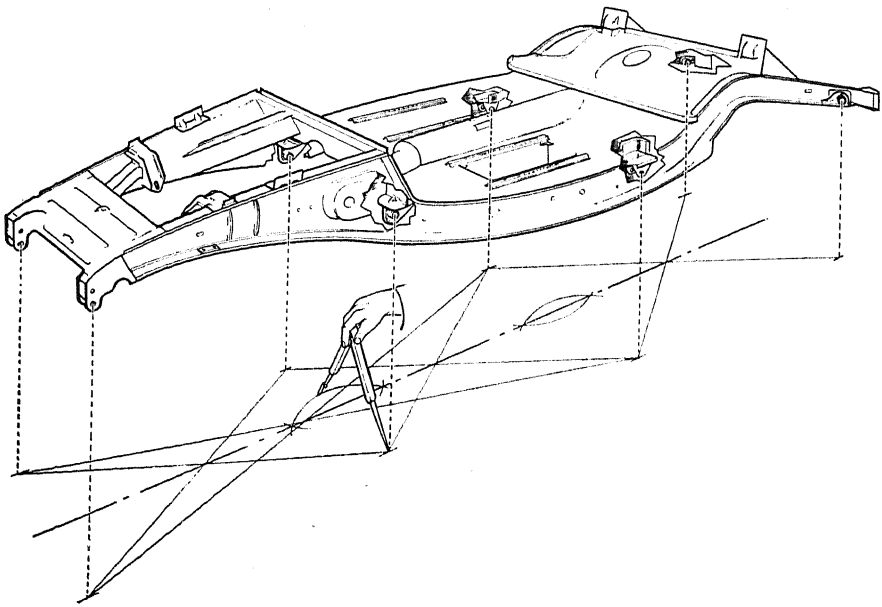


Fig. 37.—THE METHOD OF CHECKING THE ALIGNMENT OF THE FRAME RECOMMENDED BY MORRIS MOTORS LTD.

Verticals are dropped from the spring mountings with a plumb-bob on to the floor and centre lines and diagonals drawn.

Each pair of spring-bolt-hole marks is then engaged by a compass and arcs drawn at the centre of the chassis to locate the exact centre between them. A chalk line is then employed to draw a centre line on the floor, the line being held taut and coinciding with the extreme markings at the front and rear ends of the chassis. A chalk mark is then made on the floor by the usual method of raising the line a few inches and letting it spring back into position.

If all the remaining centre-line marks coincide with the chalk-line marking, indication is clearly given that this item of alignment of the frame is satisfactory.

A further check should, however, be applied by drawing diagonal chalk lines joining the various spring-bolt locations, duplicating them from each side so that they intersect on the body centre line. If their intersection joint does not lie on the centre line it indicates that the frame alignment between these joints is defective, and careful consideration, and measurements in accordance with the drawings herewith, will show in which direction the frame must be set to rectify matters.

Before rectifying frame misalignment make sure that you are applying the rectifying force at the right point and to the right extent.

In the case of a severe accident involving the front end of the car, the

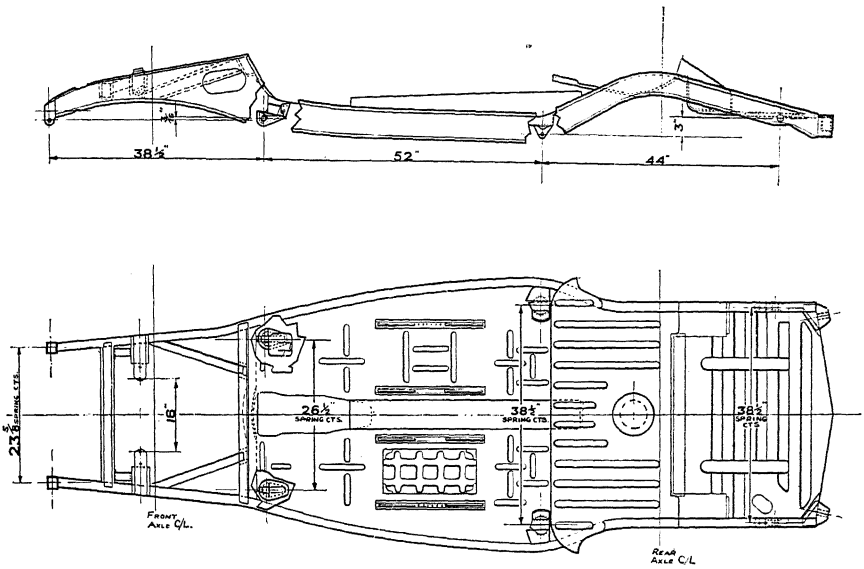


Fig. 38.—THE PRINCIPAL DIMENSIONS OF THE MORRIS TEN (SERIES "M") FRAME

alignment of the engine mounting brackets may be affected, in which case the use of a special alignment jig is recommended. Such a jig is obtainable from the Service Parts Department of Morris Motors Ltd., Cowley, Oxford. This jig is located to the front spring-anchorage brackets by means of a fixed mandrel, and to the front spring-shackle bracket by the screwed shackle pin, and therefore also serves as a check on the correct position of the front spring shackle and anchorage bolts.

A detachable plate is provided with the jig for checking up the engine-bracket holes, having a dowel and hole at one end for location to the engine bracket with a setscrew, and an extension to the other end which engages a slot in the jig. Provided the detachable plate can be assembled with its end engaging the slot in the jig it may be taken that the engine brackets are in proper alignment in relation to the front spring brackets.

Breaking Welded Joints

Having carefully examined the damage, and decided, in cases of extensive damage, where the new panel units will be joined, the next step is to remove the damaged portions.

Most of the parts are joined together by spot welding and this method precludes parting of the joints with a cold chisel and hammer, as this tends to distort and tear the panel. The only satisfactory way to separate spot-welded joints is to drill out the centre of each spot weld with a $\frac{3}{16}$-in.

or ¼-in. drill. Actually it is not necessary to drill right through the two panels ; if the point of the drill just begins to break through the second panel it will be sufficient, and the two panels can then be separated quite easily by inserting a sharp cold chisel between the joint and tapping it lightly with a hammer.

Where the position of the original spot welds is hidden by paint a suitable liquid stripper will have to be applied to reveal the welds, which are then easily located by the discoloration of the metal.

Gas-welded joints are best separated by cutting with a hacksaw whenever possible. If the location of the weld is awkwardly placed a sharp cold chisel will have to be employed, but it is not so satisfactory as a hacksaw.

Several of the lap joints in the body, notably those at the junction of the windscreen panel with the side panel, and the trunk panel with the side panel, are sunk below the level of the surrounding panel, and the channel thus formed is filled with plumber's solder to provide an unbroken surface for the paintwork.

To expose the joint it is necessary to melt the solder and wipe it away, using a blow-lamp or oxy-acetylene blow-pipe to obtain the necessary heat.

When the solder has been wiped away the joint can be broken by drilling out the spot welds, as already detailed.

At its forward end the roof panel is butt welded to the windscreen panel, and when required this joint can be broken by the use of a cold chisel and hammer, directing the blows of the hammer towards the panel not required. In case of difficulty in breaking this joint a little heat may be applied to the weld with the oxy-acetylene blow-pipe, to soften the fused edges of the weld, or alternatively the joint may be cut with a hacksaw.

When remaking spot welds the two panels should be welded, through the holes drilled for separating the panels, by gas welding, in the manner described in the section on the general repair of all-steel bodies.

Replacement of Panels

Although in the majority of cases it will be found possible to rectify the original panels if care is taken, in certain cases of extensive damage it may be found more economical to cut away the damaged portions and employ the replacement panels available.

It will, however, usually be found that the damage is localised and that a complete replacement panel will not be necessary. In most cases the damaged portion can easily be cut away and a replacement cut from a corresponding panel and fixed in position by gas welding.

For instance, should a door pillar be badly damaged it would obviously be uneconomical to replace the whole side panel. The correct procedure would be to cut away the pillar and replace it with a pillar cut from a

replacement side panel. This would of course mean buying a complete replacement side panel just the same, but it is more than likely that the remaining portions left over will be required for another repair job at a later date.

It is to be noted that Morris Motors will sell only complete panels, and will not divide them up.

Special Features

Apart from the monopiece construction the Morris Series "M" Ten employs certain other features which are not common to other cars.

The door assemblies, for instance, are made up entirely from steel pressings, and have no wood in their construction, while the front-door window lift is cable-operated.

Since the doors are of all-steel construction they will not warp under the action of the weather, and the only thing which will interfere with their fit is accidental damage.

The methods of regulating the proper shutting of the door are exactly as indicated in the section dealing with the general repair of all-steel bodies.

Removing Front-door Glass

First remove the bakelite window frame, which is held in position on the door by eight chromium-plated screws of the self-tapping type. This will enable you to remove the door trim panel after withdrawing the window regulator and door-lock handles (which are held on to their spindles by cheese-headed screws and spring washers), slackening the screws holding the door pin plate to the door frame, detaching the finishing plate for the pin plate, and removing the eight self-tapping screws which attach the door trim panel to the door frame.

Removal of the trim panel reveals the window-winding mechanism and permits the removal of the inner glass draught-excluder, which is held in position by four self-tapping screws.

It will be seen that the glass channel is attached to the operating cables by two clamps. Unscrew the two cheese-headed screws in each clamp and extract the rubber stop upon which the glass channel rests when the glass is in the "down" position.

The outer draught strip for the door glass is then removed from the door frame by prising out the four spring clips which form part of it.

The front guide channel must now be detached from the door frame by unscrewing the cheese-headed screw at the top end, and the hexagon-headed setscrew at the bottom end, which are located in the depressions of the inner door panel.

The glass should then be raised and turned towards the front of the car so that the top edge of the glass faces forward, when no difficulty will be encountered in removing it.



Fig. 39.—REMOVING FRONT-DOOR GLASS

Showing the manner in which the front-door glass is raised and rotated forward for removal. (*Morris Motors Ltd.*)

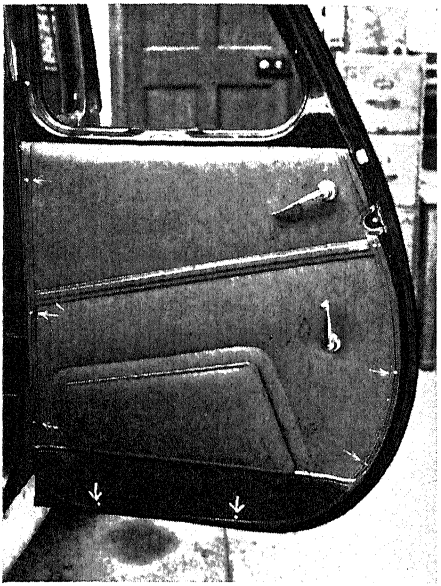


Fig. 40.—FRONT-DOOR TRIM

Here are shown the series of screws which attach the front-door trim panel to the door frame. (*Morris Motors Ltd.*)

The window-felt guide channel is fixed to the door frame by seven countersunk-headed self-tapping screws, and cemented to both front and rear metal channels with "Bostick." Once the glass is removed this guide channel can be removed quite easily when necessary.

Front-window Regulators

These are of the cable-actuated type, and provision has been made for adjustment of the cable tension, when necessary, by mounting the two lower pulley spindles in elongated holes in the door-frame panel.

Adjustment is effected by slackening the pulley spindle nuts and removing the spindles in the required direction. There is enough adjustment provided to enable fresh cables to be introduced without the necessity for removing the pulleys.

The cables are actuated by a chain passing over a sprocket attached to the regulator spindle by a $\frac{3}{16}$-in. nut. This nut can be reached by introducing a $\frac{3}{16}$-in. spanner behind the inner door panel.

Replacing the Front-door Glass

First of all the regulator chain should be moved so that it extends as far as possible towards the top of the door.

The glass, complete with its channel, is then inserted in the door frame and lowered so that it rests squarely on its rubber stop.

The glass channel is then attached to the operating cables by replacing the fixing clamps and their screws.

Following this the remaining components may be replaced in the reverse order to their removal.

Removing Front-door Locks

Remove the outside door handle by unscrewing the two plated screws which attach the escutcheon plate to the door panel. In the case of the offside handle, which incorporates the private lock, this is in addition secured in position by countersunk-headed screws inserted in the inner end of the spindle, and this must naturally be removed before the handle can be withdrawn.

Raise the glass to the fullest extent and release the front guide channel from the inner panel as already described.

Removal of the four lock-retaining screws, two on the door shut face, and two on the inner door panel, will enable the lock to be withdrawn.

The Door Checks

The door checks are of the metal type, consisting of a metal check arm passing though the door frame and a resilient buffer to which it is located by a metal collar which engages slots in the end of the check arm.

Access to the door checks is obtained by removing the door trim panel.

If it is required to remove the door-check assembly this is carried out by extracting the rivet attaching the check arm to the lug on the door pillar, and withdrawing the check assembly from inside the door frame.

When replacement parts are fitted the door check components should be replaced in the following sequence:

The buffer should be

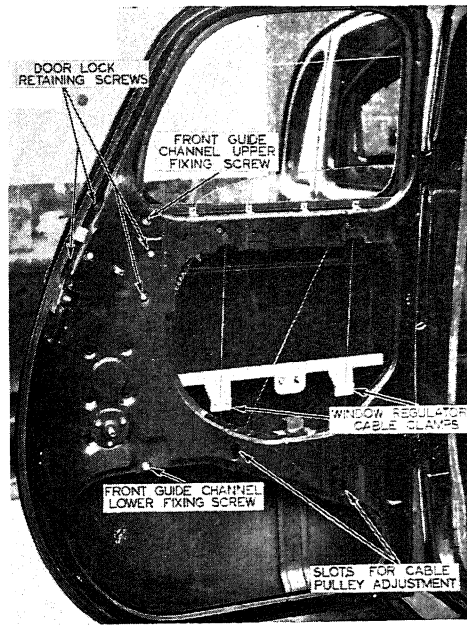


Fig. 41.—THE LOCATION OF SOME OF THE ATTACHMENT SCREWS FOR THE VARIOUS DOOR FITTINGS AND THE CABLE-PULLEY ADJUSTING SLOTS. (*Morris Motors Ltd.*)

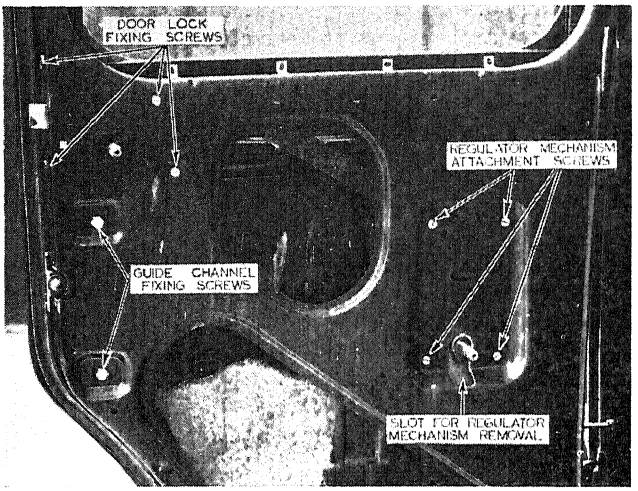


Fig. 42.—THE POSITION OF THE SCREWS ATTACHING THE DOOR LOCK, WINDOW REGULATOR, AND GUIDE CHANNEL ON THE REAR DOOR

Also shown is the slot required for removal of the regulator mechanism. (*Morris Motors Ltd.*)

threaded on to the slotted end of the check arm—small end first.

The tongued and slotted retaining washer should then be inserted in position on the end of the check arm, hollow side outwards.

The slotted rubber stop-washer should next be slid into position, followed by the slotted metal retaining washers.

Care should be taken to ensure that the front and rear doors do not meet when both are opened to their fullest extent. The maximum door opening can be adjusted by inserting the slotted retaining washer in the appropriate slot in the check arm, after which it can be locked in position by bending down the two ears of the retaining washer into engagement with it.

Door-sealing Rubber Strip

The rubber weather-sealing strip which runs round the front and top edge of the doors can easily be removed for replacement by pulling it out with a pair of pliers or similar suitable tool.

The ends of the channels holding the strip in position are lightly peened over to ensure that the rubber strip does not creep out of the channel. Before replacing the rubber strip prise out the channel ends to their normal dimensions.

When fitting a new rubber sealing strip insert one side into the metal retaining channel, and then press in the other side into the opposite recess of the channel with a blunt screwdriver, using a sliding motion.

When the rubber sealing strip is properly inserted in its retaining channel, lightly peen the ends of the channel to make sure it remains in this position.

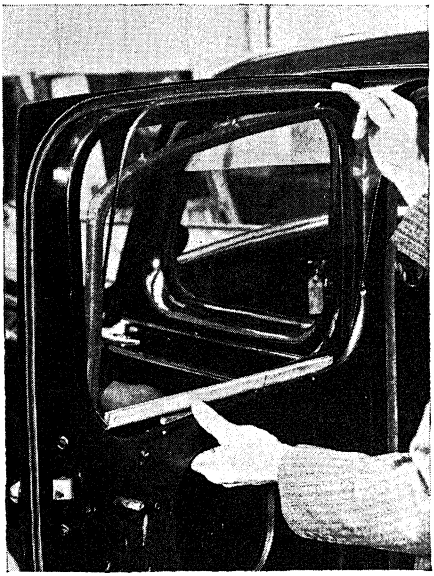


Fig. 43.—WITHDRAWING REAR DOOR GLASS
Raise glass upwards and tilt it inwards, after removing the necessary components. (*Morris Motors, Ltd.*)



Fig. 44.—THE METHOD OF WITHDRAWING THE RUBBER ROOF DRAIN PIPES (*Morris Motors, Ltd.*)

Rear-door Window Regulator

The window regulators on the rear doors are of the rack-and-pinion type, and access to them is obtained by removing the door trim panel in the same way as on the front doors.

The regulator mechanism is attached to the inner door panel by four cheese-headed screws at each corner of the panel recess. Removal of these screws and their spring washers will enable the regulator arm to be detached from the glass channel, and the regulator assembly withdrawn.

A few of the early models of this series possessed a circular hole in the inner door panel through which the regulator spindle passed. In such cases it is necessary to elongate this hole downwards to the edge of the panel depression in order to permit withdrawal of the regulating mechanism.

Removing Rear-door Glasses

To withdraw the glass from the door frame it is necessary to remove the bakelite surround and door trim panel as already described, release the regulator from the inner door panel, and disconnect the regulator arm from the glass channel. It is, however, not necessary to remove the regulator entirely from the door frame.

If the felt guide channel is detached from the door frame by removing the eight countersunk attachment screws, the glass can be withdrawn by raising it upwards, tilting it inwards at the same time.

The felt of the guide channel is secured in its metal retainer by "Bostick," and it can be withdrawn for replacement after extraction of the door glass.

The rear metal guide channel is retained in position by two $\frac{3}{16}$-in. hexagon-headed screws and spring washers.

Removing Rear-door Locks

Before removing the lock of the rear door it is first necessary to remove the door glass and metal channel as already described, and also the door handle by removing the two escutcheon screws. It is then an easy matter to remove the lock assembly after unscrewing the two screws on the shut edge of the door and the two screws on the inner door panel, which locate it in position.

The Sliding-head Assembly

To remove the sliding-head assembly open the sliding panel approximately halfway and remove the cheese-headed screws which attach the two guide plates to the two forward corners of the sliding panel, levering the guide plates outwards to disengage them from the runners.

The sliding panel assembly can now be drawn forwards and upwards until it is clear of the body.

If the sliding panel is not closing flush, or is fouling the roof panel, its position may be adjusted when it is removed by setting the spring guides at the rear end.

To replace the roof assembly see that the centralising rod attached to the rear of the framework coincides with the slot in the rear face, and that the felt guides at the rear enter the channel of the roof runners at each side. The roof should then be pushed rearwards, lowering the front at the same time, until the assembly is in position.

The front end guides may now be replaced in engagement with the runners and their retaining screws replaced.

Should the sliding panel trimming need attention, it should be remembered that it is attached by tacks to the front and sides of the panel on to wood fillets, but that it is held by adhesive only at the rear end.

Roof Drain-pipes

Rain-water from the roof is drained away by concealed ducts which discharge the water below the body. These ducts are in the form of rubber tubes passing down the "A" posts and "D" posts, and are attached to the roof-water ducts by hose clips.

They can be withdrawn for cleaning or replacement by detaching the roof trimming for a distance of approximately 12 in. on either side of the

body post, which will give access to the hose clip, which can then be released.

In order to ensure that the drain tube can be replaced without trouble it is advisable to attach an ample length of wire to the lower end, which can be used to draw the tube back after it has been given attention.

When the hose clip has been released, the tube end can be released from the roof duct and withdrawn by drawing it into the car.

When the lower end comes through do not forget to detach the draw wire, so that it remains in place for the subsequent replacement.

Removing the Windscreen

Open the windscreen some 3 or 4 in., and release the windscreen-adjustment chain from its attachment to the windscreen by removing the cheese-headed attachment screw. The chain can now be screwed back into its housing.

From inside the car remove the $\frac{1}{4}$-in. setscrew and plated adjusting screw with raised head from each of the windscreen hinges. This will enable you to remove the screen with the help of an assistant.

Replacing the Windscreen

The windscreen is replaced in the reverse order to its removal, but it must be remembered that the $\frac{1}{4}$-in. hexagon lockscrews must not be tightened up until the screen has been correctly adjusted, by means of the adjusting screws, so that the rubber water-seal is making proper contact all round the screen panel. This adjustment should, of course, be carried out with the screen fully closed, and when properly carried out the adjustment should be locked by tightening up the $\frac{1}{4}$-in. hexagon lock-screws.

Removal of the Boot Lid

Remove the spare wheel and detach the floor of the luggage compartment by withdrawing the six countersunk screws, which are

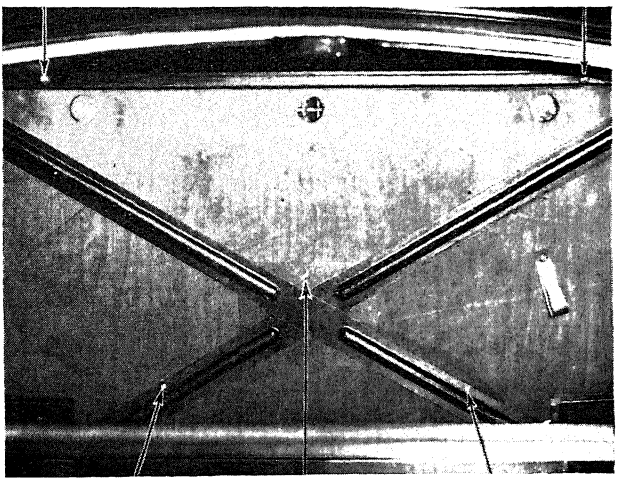


Fig. 45.—THE POSITION OF THE REAR SEAT SQUAB FIXING SCREWS (*Morris Motors, Ltd.*)

located just behind the seat squab reinforcement, and the eight countersunk screws with nuts and washers situated at the rear just inside the boot opening. Access to the nuts and spring washers is obtained through the spare-wheel compartment.

Release the hinges for the lid from the body by unscrewing the retaining screws, and fold the hinge arms against the inner face of the lid.

Remove the lock handle from the lid by unscrewing the two screws which attach the handle escutcheon in position, and the screw on the inside which passes into the spindle of the handle.

With the help of an assistant slide the lid carefully into the spare-wheel compartment, raising the rear end to clear the spare-wheel brackets and turning it sideways so that it can be withdrawn, taking care all the while not to damage the paintwork. When refitting the lid, use a tapered mandrel to line up the box nuts for the hinge screws and the screws at the forward end of the boot floor.

Removing Roof Trimming

Detach the roof-lamp switch by unscrewing its two fixing screws, and disconnect the two leads from the terminals at the back.

Remove the roof-lamp glass by withdrawing the retaining spring, thus exposing the three wood-screws, removal of which will enable the roof-lamp to be withdrawn after the leads have been disconnected. The mauve-coloured lead is connected to the insulated terminal.

Remove the bakelite surrounds from both the rear-quarter lights by removing their attachment screws, noting that two of the screws are longer than the rest and locate the surround to the " D " post. Remove, also, the rear-light surround, which is attached by ten screws.

Extract the tacks from the " Jubilee " banding finishing the edges of the roof lining, including that at the sliding-head opening and the windscreen top rail, and then extract the remaining tacks holding the lining.

This leaves the trimming supported only by the two support rails at the domed portion of the roof at the rear, and it is finally released by removing the eight wood-screws which hold the support rail in position, permitting its withdrawal complete with support rail.

The Seats

The front seats are released by removing the cheese-head stop-screw from the forward end of each seat runner. Raising the seat catch then enables the seat to be pulled forward clear of the runners.

In the case of the rear seat, the seat squab is attached to the rear of the body at five points, access to which is achieved through the luggage boot.

There are two attachment nuts located on the rail just below the rear light, and three countersunk screws, one passing through the rectangular stiffening plate in the centre of the " X " bracing member and one approximately halfway down each of the lower members of the " X " brace.

OVERHAUL OF 7-H.P. AND 10-H.P. AUSTIN REAR AXLES

By W. W. MEAD, M.I.M.T.

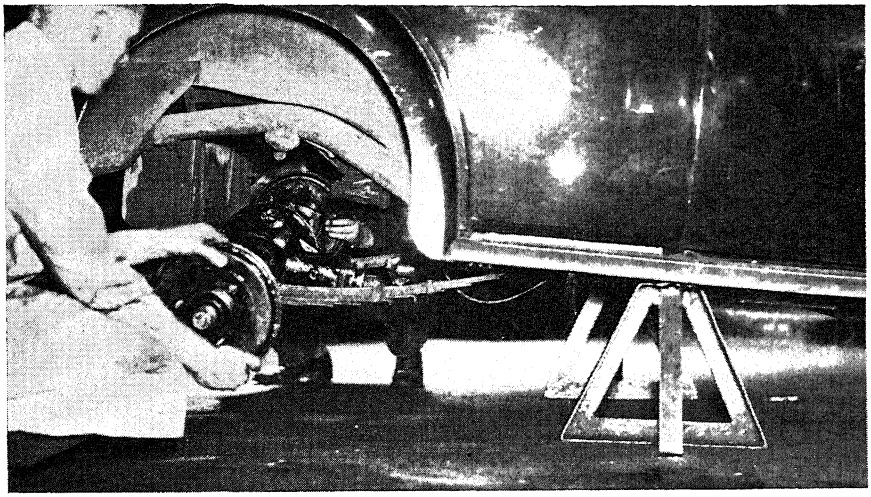


Fig. 1.—Removal of Axle

Showing position for the trestles and the axle being passed out from the side of the car.

10-H.P. MODEL

IN dealing with rear-axle repair the same procedure should be followed as with other units. Test and ascertain from an outside diagnosis, if possible, the cause of trouble. In the case of complete failure, of course, the trouble will be obvious when the axle is dismantled, but the complaint is generally of undue noise. Axle noises can be divided into three classes: (1) Humming or whining, (2) Roughness, (3) Knocking. Take the complaints in order.

Humming or Whining

This is usually caused by an incorrectly meshed crown-wheel and pinion. They can both be adjusted independently, and this is invaluable when fitting a new pair. But if an axle has run long enough for the wheels to have become mated, adjustments are of little use, and it is very

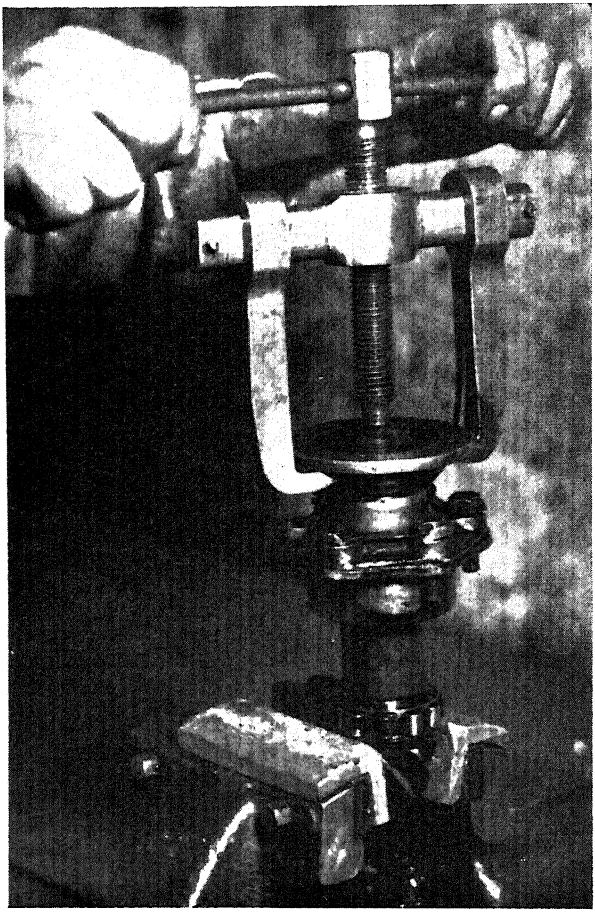


Fig. 2.—DRAWING THE BEVEL SHAFT WITH THE AUSTIN UNIVERSAL EXTRACTOR

doubtful if an improvement can be made by the use of them. During the early life of the car the insertion or removal of a shim or shims at the bevel pinion may quieten a noisy axle, but adjustments cannot be made to the crown-wheel adjusting collars whilst the axle is under the car because the petrol tank is in the way. The only alternative to adjustment is the removal and dismantling of the unit and refloating of the crown and bevel. It may even be found necessary to replace these parts.

Roughness

Roughness is usually caused by defective ball races. Before dismantling the axle, remove the bevel pinion and examine the races on the assembly. If any of these are defective they should be replaced and an effort made to adjust the position of the bevel to the crown-wheel with shims.

Knocking

This is usually caused by a chipped tooth or teeth of the crown-wheel or bevel pinion. Replacement is of course necessary. A chipped ball or roller in a race can cause intermittent knocking. Having decided dismantling is necessary, proceed in the following order :

Removal of Axle

Jack up the car under the chassis frame just forward of the rear axle. It is best to raise the car on a high-lift jack from the centre of the rear axle and let it down again on trestles in the position mentioned. Now disconnect the propeller shaft by taking out the bolts holding it to the bevel-pinion driving flanges. Remove the rear road wheels. Disconnect the shock absorbers where connected to the axle case and push them up out of the way. Take out the pin holding the brake cable to the pivot near the centre of the axle case. Remove the spring clips which hold the axle to the road springs ; now remove the axle by passing it out sideways from the car between the rear spring and the chassis frame (Fig. 1). (Take care of the wood packings.)

Dismantling

Holding the axle with the bevel gear facing upward, take out the bevel drive by removing the six setscrews holding it to the axle case. (Don't lose the shims.) The outer track of the roller race will remain behind in the case, and can be knocked out later. Turn the axle over and let the lubricant drain out. Hold the gear in the vice between lead clamps and knock up the locking washer of the driving-flange nut and remove the nut with a box spanner. Now draw off the flange with a claw driver (Fig. 2).

The bearing cap, housing, oil seal, compound race, distance-piece, and centre track and roller of the race will come off by banging the screwed end of the bevel shaft on a wooden or lead block.

Hold the axle casing in the vice horizontally. Take off the brake drums, after removing the two countersunk screws

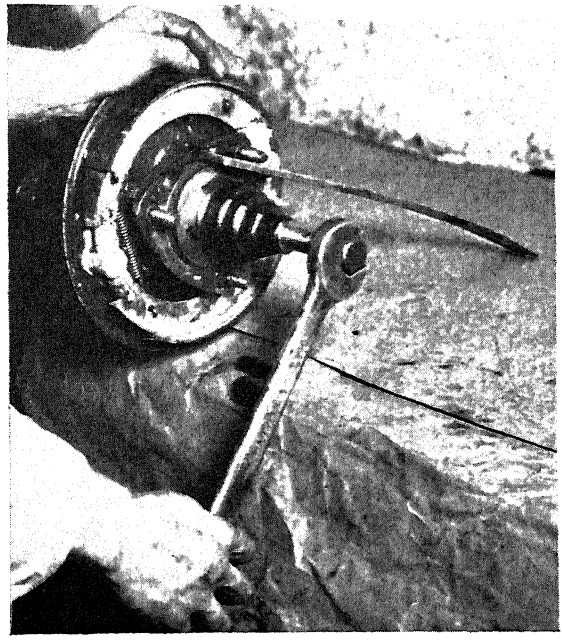


Fig. 3.—DRAWING OFF THE HUB

Showing the lever in position to prevent the hub turning.

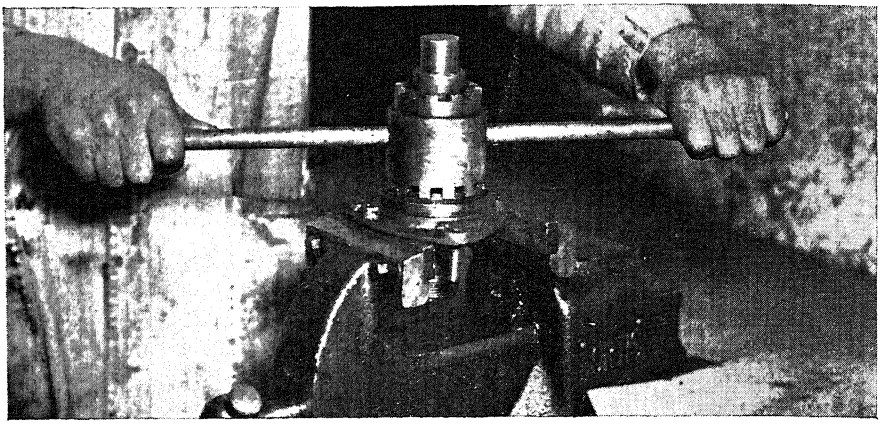


Fig. 4.—THE SPECIAL SPANNER FOR FITTING OR REMOVING THE HUB RACE CLAMPING NUTS

which hold them to the hubs. Take out the axle shaft split-pins and nuts. By placing a lever between two of the studs and letting the end rest on the bench the hubs can be held whilst the nuts are loosened (Fig. 3). Now draw off both hubs with a hub drawer. If the brakes are not to be relined mark their position with chalk, also the drums.

The hub roller race is held in position by castellated locking ring. This is in turn locked in position by a locking washer held by a setscrew. A special spanner is made by the manufacturers for removing this ring (Fig. 4). It can be loosened by a hammer and drift, but care should be taken not to mutilate it. The inner track will remain on the end of the axle casing, and can be removed later if necessary.

Remove the setscrews holding the two halves of the axle case together. These are fitted with spring washers. Now take off the nearside or small half of the casing. Then draw out the cross-shafts complete with the differential casing and crown-wheel. Remove the bolts holding the two halves together. Remove the cross-shafts, the differential wheels, and centre.

Going back to the offside axle case, remove the setscrew holding the outer track of the bevel-pinion roller race and knock the track out. Carefully knock the differential roller races off the cases and then thoroughly wash all parts.

Examining Parts for Wear

After all the parts have been washed the races should have a final clean in perfectly clean petrol and then be examined for wear; use a magnifying glass to examine the rollers or balls.

Test the differential thrust races by holding them in a vice, with the

faces marked "thrust" together. Try two feelers at once between the outer tracks. If larger than ·002 in. passes, renew them.

The roller and compound races should be examined for wear or roughness and renewed if necessary. Look to the bores of all races and make sure they have not revolved on their shafts and worn. Try the hub roller races on their inner tracks; do not remove the inner tracks from the cases unless they need renewing, because they are difficult to punch off and are likely to be injured during the process.

A word might be said here regarding the earlier type of 10-h.p. car, when ball races were fitted to the hubs. It has been known for the inner track of these to revolve on the casing and wear a recess in it. The remedy is to expand the end of the case if the wear is not more than ·010 in. If more, it is possible to obtain races from the manufacturers ·075 in. undersize in the bore. The case should be turned down to fit.

Examine the bevel-shaft distance-piece and make sure this has been clamped tight. If there is any sign of the races having moved against the ends, renew it.

All axle cases, cross-shafts, and the differential cases should be tested for truth. Any excessive end float of the cross-shafts should be taken up by fitting new bushes to the differential cases. A running clearance of ·002 in. should be allowed between the end of the cross-shaft pinions and the differential centre.

Carefully examine the bevel pinion; if there is any sign of picking-up, namely if the teeth are rough and look as if they have tried to seize up to the crown-wheel teeth, they should be renewed.

Now examine the crown-wheel teeth: this often shows more evidence of noise than the bevel gear; look along the teeth for any lines or indentations or signs of wear taking place in a series of flat surfaces, or wear taking place more at one end of the teeth than at the other. If any of

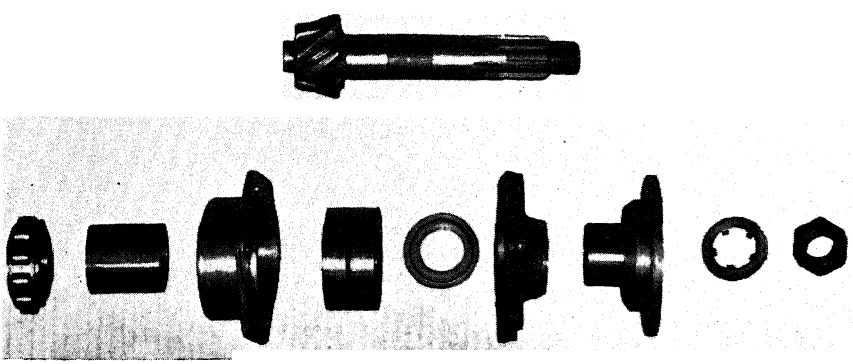


Fig. 5.—THE PARTS COMPRISING THE BEVEL-DRIVE UNIT OF THE 10-H.P. MODEL AND THEIR ORDER OF ASSEMBLY

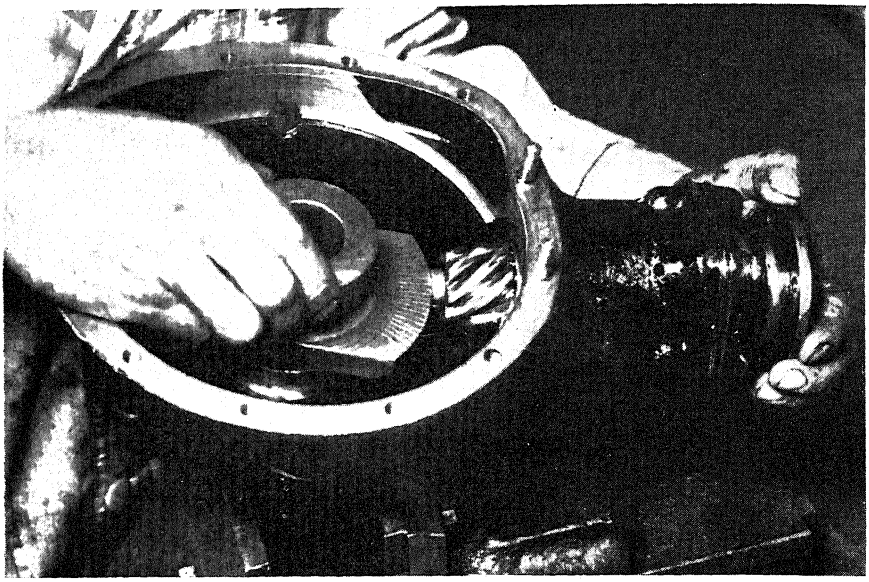


Fig. 6.—THE SPECIAL CROWN AND BEVEL-MESHING TOOL IN USE

these conditions show they should be renewed. It is possible to obtain crown-wheels and bevels only in pairs. They are ground in pairs and never parted. They are each marked with a number, and it is always wise to check up when buying a new pair to see that the numbers match.

Take this opportunity of examining the Girling-brake housings. Clean and repack them with the special grease necessary, namely Keenol KG 20.

Assembling the Axle

Having decided on the new material necessary, the axle can be built up. Start with the bevel drive. The order of assembly is first the roller race, then the distance-piece, next the compound race assembled in the housing, now the bearing cap—not forgetting to fit a new oil seal, lastly the bevel-driving flange (Fig. 5). Use a new locking washer. The whole assembly is held by the bevel-shaft nut, and care must be taken to ensure the nut is tightened right home before the lockwasher is turned over. Use a box spanner and a long tommy bar. Give the housing a sharp blow with a mallet to ensure the bearing has gone right home before the final tightening up.

Correct Meshing of Wheel and Pinion

The proper way of ensuring the correct meshing of the crown-wheel and bevel pinion is to assemble them with the help of the gauge made for

the purpose by the manufacturers (Fig. 6). The gauge locates in the offside axle-case bearing housing, and is free to revolve. The periphery of the gauge is eccentric and is marked in one-thousandths of an inch. On both the crown-wheel and pinion, figures are etched, as example $\frac{5}{2}\frac{9}{5}\frac{4}{3}\frac{6}{5}$. As already stated, the number should always be the same on both parts. The bottom figure is the one to set the gauge to. The necessary number of shims should be fitted between the bevel housing and the axle case, so that when the six setscrews are tightened down the gauge will just touch the end of the bevel gear with the line (in this case 25) at the centre of the gear. This method ensures that the pair of gears run in exactly the same relative position as that in which they were ground together when made.

Without this tool one has to use the " hit and miss " method of getting a full meshing tooth and the right amount of slack by adding and removing shims until a quiet running position is obtained. When the bevel drive is in position, refit the roller-race locking screw.

Assembling Differential Assembly

Now turn to the differential assembly. If a new crown-wheel has been fitted, bolt the two halves of the differential cases together without

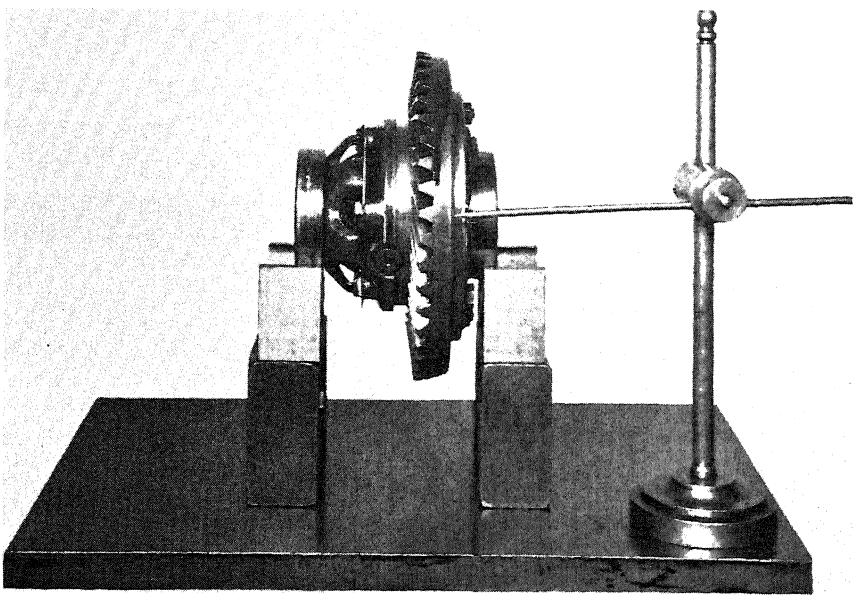


Fig. 7.—TESTING THE CROWN-WHEEL FOR TRUTH AFTER BOLTING IT TO THE DIFFERENTIAL CASE

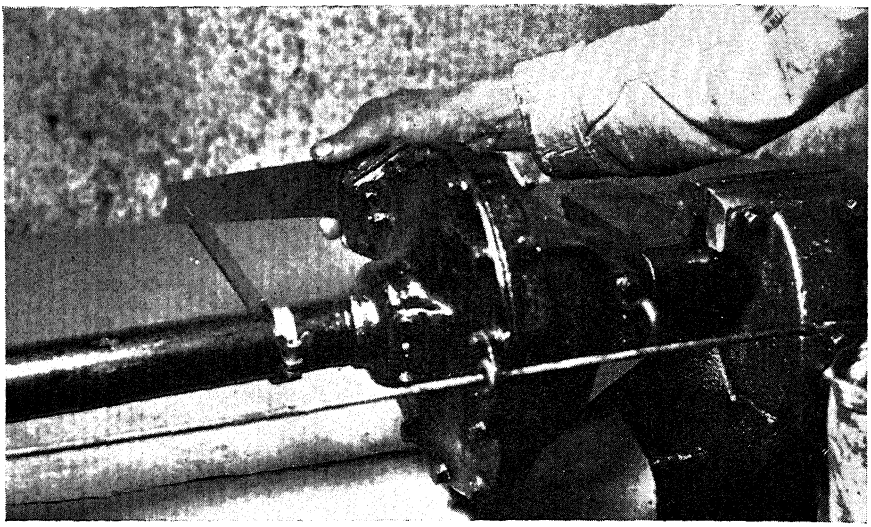


Fig. 8.—TESTING THE BACKLASH BETWEEN THE CROWN-WHEEL AND BEVEL

the centre. Tap on the thrust races, making sure the side marked "thrust" is outward, and placing the whole on a pair of V blocks, revolve the case and test the crown-wheel with a scribing block for truth (Fig. 7). Now open up the case and reassemble with the cross-shafts, differential wheels, and centre. Smear a coating of oil on all parts as they are assembled. Take care the bolts used are in good condition, and the threads not stretched. Use new lock washers. The differential-case bolts are of a special high-tensile steel, and should be obtained only from the manufacturers or their agents. Hold the offside axle case in the vice with the centre upward. Drop the assembly, complete with cross-shafts, into the case. Use a new brown-paper washer and fit the nearside case. Tighten the setscrews of the two halves evenly, and finally adjust the collars to control the backlash and thrust of the differential assembly.

Adjusting Differential Assembly

The method of checking this is to fit a bar of metal or wood across the bevel-driving flange. Make a mark on the bar 7 in. from the centre. At this mark the backlash should be $\frac{1}{16}$ in. (Fig. 8). Having adjusted the backlash take up all end thrust with the nearside adjusting collar.

Before fitting the hubs examine the brake shoes, and if the liners are worn fit relined shoes. If the wear is not severe it will no doubt be found that one liner on each hub is worn more than the other. This is on the trailing shoe. Change them over. On the type of shoe where the springs fit direct into the shoe the top can be placed to the bottom on the same

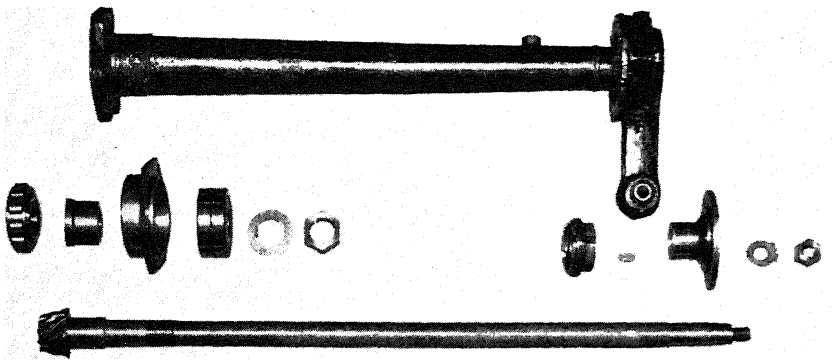


Fig. 9.—THE BEVEL SHAFT AND TORQUE TUBE OF THE 7-H.P. MODELS
Showing the order of assembly. The small ball race is in the front end of the torque tube.

hub, but on the type where the springs are anchored on pins it will be necessary to change the shoes to the opposite hub, making the bottom shoe of one side become the upper shoe of the other.

When replacing the hubs use new oil-sealing washers. When filling the axle place it in the same relative position as it will be on the car, to ensure it will not be over-filled. Bear in mind that a high-press lubricant should be used—one of the grades recommended by the manufacturers.

The refitting of the axle is a simple operation, carried out in reverse to removal.

7-H.P. AND BIG 7-H.P. MODELS

The construction of 7-h.p. and Big 7-h.p. rear axles is the same, but they are somewhat different from the 10-h.p. One of the differences is in the arrangement of the bevel drive, which consists of a long shaft housed in a torque tube. The forward end of this tube is spherical and fits into a housing with freedom to move, the whole housing being anchored to a silent-block bush which fits into a bracket bolted to the cross-member of the chassis frame. The shaft revolves on three bearings, one roller and 1 compound thrust-race at the bevel end, and a ball race at the front end. A left-hand threaded nut and tongued locking washer clamps the rear-end races and distance-piece (Fig. 9).

The points alluding to the diagnosing of trouble on the 10-h.p. model apply equally to the 7-h.p. It is more common, however, for roughness to develop in the races on the torque tube on the 7-h.p. model than on the bevel shaft of the 10-h.p.

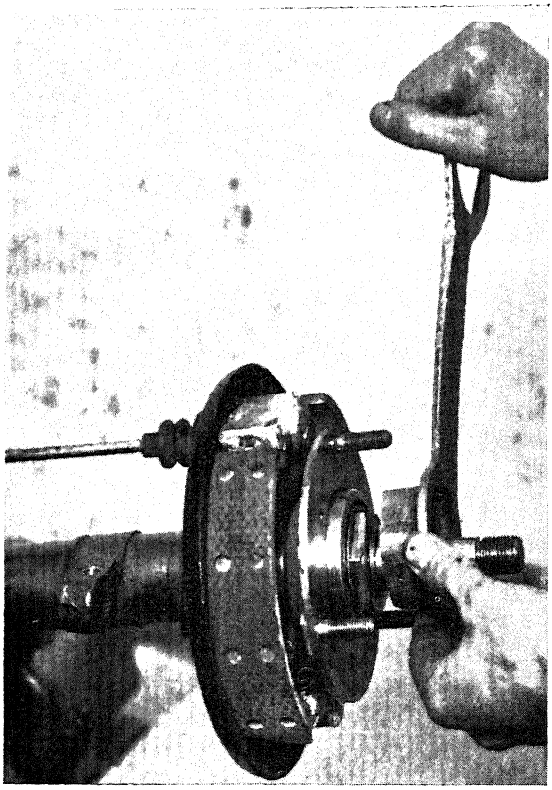


Fig. 10.—SHOWING THE CLAMPING NUT OF THE REAR HALF HUB

Rear Axle Removal

The method of removal for the 7-h.p. model is as follows:

Place trestles under the car at the rear cross-member. Take out the bolts holding the bevel-shaft driving flange to the propeller shaft. Now remove the bolt holding the spherical housing to the silent-bloc bush, or torque anchor as it is termed. The housing will now pull up and away from the bracket. Disconnect the shock absorbers at the bottom links, and the brake cables or rods from the brake cams or levers.

It should be mentioned here that the small 7-h.p. car has Girling-type shoes coupled to the old-type brake cams and cables. The Big 7-h.p. has full Girling brakes right through.

Remove the rear hubs. To do this take off the road wheels and take out the three countersunk screws which hold the drum and two halves of the hubs together. Remove the axle-nut split-pin and nut. Now with a hub drawer pull off the front half of the hub. When the front half hub is removed the locking nut for the ball race and rear half hub is revealed (Fig. 10). Knock up the lock washer and remove the nut with a box spanner. The back half will usually then lever off. If it is tight, replace the front half and tighten it to the back half with the wheel nuts and pull the whole off with the hub drawer. Mark the brake shoes so that their original position can be easily found.

Now remove the cotter pins which lock the spring pins to the axle case. On the Big 7-h.p. the spring pins screw out of the case. On the small 7-h.p. they knock out.

Support the weight of the axle on a box or trestle before removing

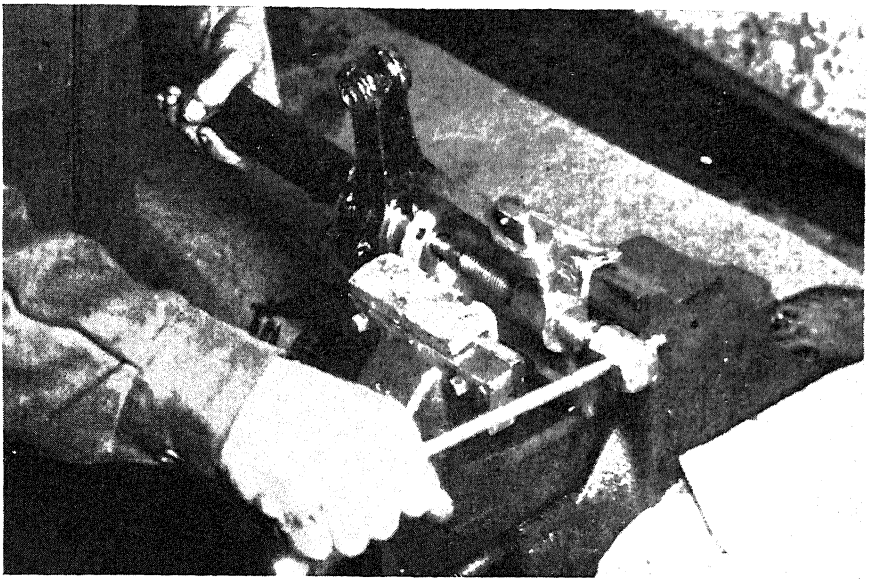


Fig. 11.—WITHDRAWING THE DRIVING FLANGE FROM THE BEVEL SHAFT (7-H.P. MODELS)

them. The axle can now be pulled from under the car, raising the spherical housing to clear the cross-member.

Dismantling

When the axle is removed from the car take out the six bolts which hold the torque tube to the axle casing and pull it out. Remove the nut holding the driving flange to the shaft. With a drawer pull off the flange and take out the key (Fig. 11). Now drive the shaft out of the tube. The pinion-bearing sleeve will tap off the roller bearing. Unscrew the brass gland nut and tap out the front ball race. Knock up the lock washer and unscrew the pinion-bearing nut from the bevel shaft. The thread of this is left hand. Remove the races and distance-piece from the shaft. Turning to the axle case, take out the six screws holding the two halves together. Pull off the nearside or small half and lift out the differential assembly end cross-shafts complete. Open up the differential assembly end cross-shafts and differential wheels. Wash all parts ready for inspection. Test and examine them all in the same manner as for the 10-h.p.

Assembly

The procedure for reassembling the axle is the same as for the 10-h.p. Fit the races on to the bevel shaft. First the roller race, then the distance-piece, lastly the thrust compound. Take care to get the locking nut very

tight before turning over the lock washer. When assembled, insert the shaft in the torque tube, tap the front ball race into position, and clamp it with the brass gland nut. Fit the key, then the driving flange, and again take particular care to get the nut holding the flange very tight before locking with the washer. The floating of the crown-wheel and bevel is carried out in the same way as for the 10-h.p. model. Adjustment for backlash is also the same. End float cannot develop in the cross-shafts of this model in the same manner as on the 10-h.p. because it is governed by the hub races. These should, of course, be examined and replaced if necessary. When fitting and adjusting the spherical housing there should be no slackness, but it should be movable on the sphere.

EXAMINING A CAR FOR ACCIDENTAL DAMAGE AND FRAME REPAIRS

By A. A. BLAKER, M.I.A.E., A.M.I.M.E.

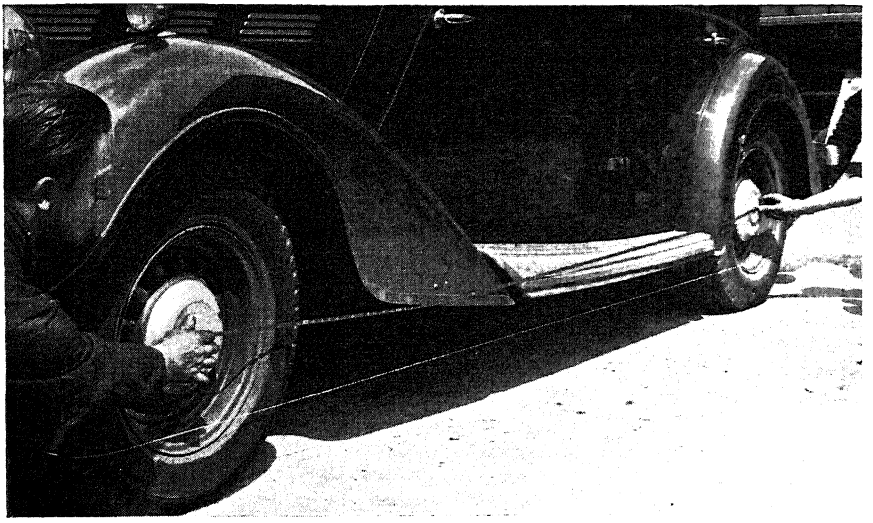


Fig. 1.—CHECKING DISTANCE BETWEEN WHEEL CENTRES

ONE of the most important branches of repair work is that which deals with cars damaged in service, by impact, or which have overturned or otherwise been subjected to abnormal strain.

Most of this work is paid for by various insurance companies, and these companies employ skilled engineers who expect competent repairers to be able to estimate accurately the amount of damage, the extent of dismantling required to enable this to be put right, and the total cost of the work.

Usually the frame of the car suffers to some extent, and it is naturally of very great importance to ensure that this member is correct, and the repairer should be able to check this without dismantling the car or at least with the minimum of dismantling, and in this connection the writer's experience in dealing with many thousands of accidents may prove useful,

more particularly to those repairers who do not specialise in this work, but have occasionally to deal with damaged cars.

Modern Frame Design

The design and method of construction adopted in the manufacture of modern motor-vehicle frames have entirely changed during the past few years ; for whereas most frames were formerly made from steel channel sections riveted together, they now consist of steel stampings or pressings welded together to form a box-section type of construction, braced with pressings of various shape, welded diagonally or at right angles to the side-members ; various fittings are also welded on so that they are no longer detachable.

The appearance of many of these frames will probably strike the repairer as being rather rough, owing to the welding methods used, but cost of production is cut to the lowest limit consistent with economy, and as frames are completely covered by metal shields and mudguards, the finished appearance of the frame is not so important as previously.

When accidental damage occurs, there is now rather more difficulty in determining the amount of resulting distortion, as, owing to the diversity of shapes and sections, and the absence of straight lines, the checking requires greater care.

We have therefore to choose methods of checking which ignore as far as possible the curves and angles of the frame and to work entirely from vital fitting points to locate errors. Several examples illustrating this method are given in this article.

The Likely Points of Damage

When a damaged car is brought in for inspection, a careful examination should be made, not only of the obvious damage, but of the whole of the car. If possible the driver should be questioned, so that the accident may be reconstructed ; this will often give an indication as to where the impact has caused distortion ; for instance, a direct blow on one of the dumb-irons will usually tend to push the whole side-member back, whereas a glancing blow across the front or rear may only bend the dumb-irons themselves, or at any rate, if the damage is in the front, as far as the rear engine support ; again, a blow received directly on one of the front wheels will usually bend the front axle (where one exists), and in addition the rear end of the front spring will force the spring bracket into the frame where it is fitted, and a buckling of the member will be found at this point.

If the point of impact is the centre of the front cross-member, for example when a car is driven or skids into a lamp-standard, there will usually be signs of buckling of the frame in the region of the dash, and it will have sunk at this point. If the blow is received on one of the rear wheels, the axle casing will bend and the wheel arch probably be distorted.

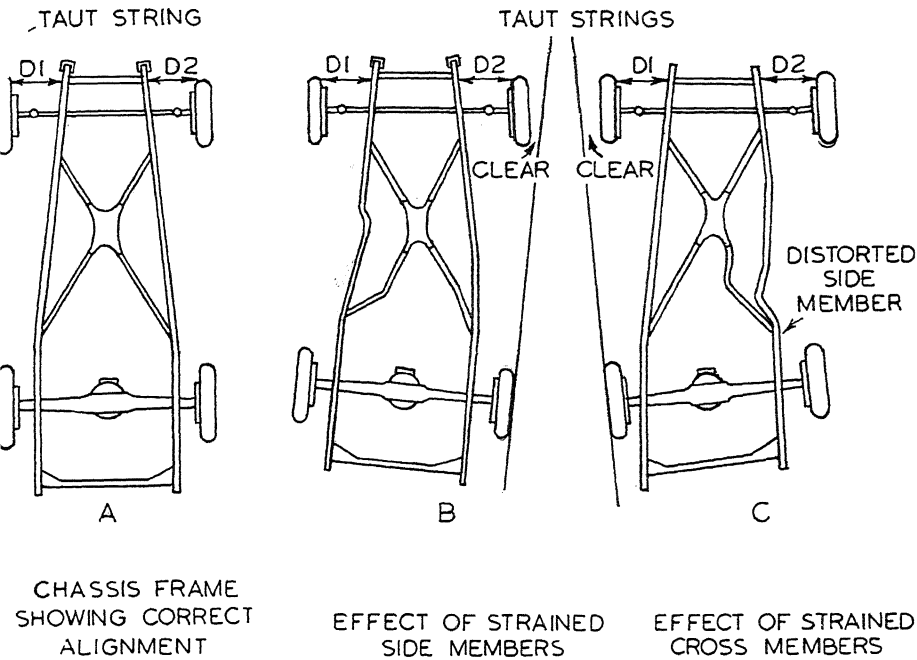


Fig. 2.—CHECKING WHEEL ALIGNMENT

Note.—In no case will D_1 be equal to D_2. When the nearside wheel is set parallel to the string, the toe-in will not allow the offside wheel to be parallel.

Examining Car without Dismantling

If the damage does not appear to be very serious, and there is no obvious reason for any dismantling, the procedure should be as follows:

(1) Jack up the car and test all four wheels for accuracy; if possible, replace damaged ones.

(2) Wheel the car on to a fairly level piece of floor, stand some distance in front of the car and try to sight the roof of the car, the radiator, and the front wings—it frequently happens that a twisted frame can be seen at once.

(3) If the car looks normal, then examine the fit of the bonnet and the way the doors close, also the windscreen.

Checking Wheel Alignment

(4) This superficial examination having proved satisfactory, the alignment of the wheels and the distance between the wheel centres on each side should be checked, the procedure being as follows:

A thin string is stretched along one side of the car, touching the rear-wheel tyre at two points sufficiently below the centre so as not to catch the spokes of the wheel if these spokes project beyond the tyre. The string



Fig. 3.—TESTING REAR AXLE WITH OPTICAL TRACK TESTER

must also touch the front tyre at the same height from the ground, and the steering wheel must be turned until the string is touching the front wheel at two points. (The front wheel is adjusted in this manner so as to bring the two front and rear wheels in line, that is, in the same plane ; and this method is better than the plan more frequently adopted of adjusting the front wheels equidistant from the frame.)

The string should now touch all four points of the two tyres ; if it does, the wheel centres on this side of the car should be accurately measured and the dimensions written down (don't trust to memory).

If the string touches at three points only, that is, two on the front wheel and one on the rear tyre, it is clear that the rear and front wheels are not in line. This may be due to the fact that some cars have a wider track on one of the axles than on the other, and if this is the case, it will be found that when the other two wheels are checked they will give exactly the same discrepancy as the first two wheels ; in this case the alignment of the two axles will be correct. It is, however, more probable that either the rear axle or the frame is bent, and this will easily be ascertained when the other two wheels are checked.

Testing for Bent Rear Axle or Frame

To decide which is the case, the next procedure is to test the front and back of the wheels on the rear axle with a track tester, and if this test shows the rear wheels to be parallel to each other, then the fault must be either in the frame or in the rear axle, which must have been shifted bodily so that it is no longer at right angles to the centre-line of the car ; this will



Fig. 4.—CHECKING FRAME ON COMPLETE CAR BY DROPPING PLUMB LINES AND MARKING ESSENTIAL POINTS ON GROUND

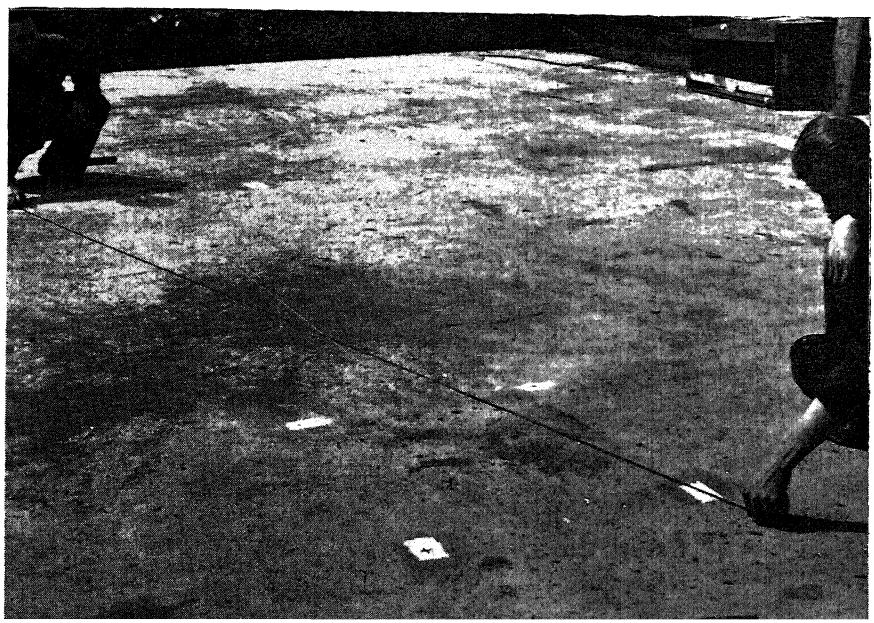


Fig. 5.—CHECKING FRAME ON COMPLETE CAR

Points marked on ground have been obtained by dropping plumb lines from car and car has been wheeled away to enable these points to be measured.

be ascertained when the opposite two wheels are lined up, the procedure being exactly the same; if the front axle toe-in is correct, it will be found that when the second side is checked the string will touch the rear point of the front tyre and will be slightly away from the front of this tyre, and the steering wheel will have to be turned to adjust the front wheel in the same plane as the rear; the wheel centres must now be taken on this side and compared with those on the other—if the measurements are within $\frac{1}{4}$ in. the car may be passed as correct.

Should this not be the case, then the body of the car must be removed to allow the errors to be corrected.

The method suggested in the previous example is particularly useful in the case of a car which has been turned over, but which exhibits no definite sign of damage.

Checking for Distortion of the Frame when Wheels or Axles are obviously Damaged

When the frame of a damaged car has to be checked and the wheels or axles are obviously damaged, but there is no definite sign of distortion of the frame, the method is as follows:

Place the car on a fairly clean and level floor. Jack up the car so that it is reasonably horizontal, and put the brake on or wedge the wheel so that the car will not move during the testing. Choose a point on one dumb-iron near the front of the frame—the anchoring pin of the front spring is suitable—and drop a plumb-line to the ground. Where the point of the plumb-bob touches, chalk the ground and draw a cross with a pencil or scriber so that the centre of the cross represents the plumb-line; do the same on the other side of the frame and mark a similar cross. Now go to the rear of the frame, and, choosing similar points, drop plumb-lines and mark two other crosses on the floor.

You now have on the ground four crosses which accurately represent the extreme corners of the frame, and if the car is moved away the dimensions of the diagonals and lengths of the side-members can be determined exactly. If opposite dimensions are within $\frac{1}{4}$ in. the frame can be passed unless the car has received impact on one side. If this is the case, further points must be taken on each side of the frame and plumb-lines dropped to the ground (suitable points are at rear of front springs and front of rear springs and one each side in the centre of the frames). You will now have five crosses on the ground on each side of the frame, and if the car is moved away, an exact copy of the essential points of the frame are pictured on the ground. The points at each end of the frame can be joined by lines and these lines bisected, and a line representing the centre of the frame can be marked by stretching a chalked string between them, carefully lifting the centre of the string and releasing it so that a white line is marked on the floor. From this centre-line all the points marked

can be checked and it is quite a simple matter to decide whether the frame is bent.

The two examples given may appear to entail a considerable amount of labour in checking, but actually this is not the case, as the written explanation of the methods employed has to be somewhat lengthy to be clearly understood.

EXAMINING CAR WHEN FRAME IS OBVIOUSLY DAMAGED

Deciding on Amount of Dismantling Required

Where the accident is of such a character that the frame is obviously damaged, the point to decide is the amount of dismantling required; some typical cases are dealt with.

First Example—Impact on Offside Front Wheel and Wing

This example is where impact has taken place on the offside front of a car, resulting in a damaged wing, bent front axle, and damage to the frame at the point where the rear end of the front spring is anchored. This frame damage may be confined to the one point alone, but more probably there will be further distortion; the frame member will be bent at least as far towards the rear of the car as the first junction of the cruciform.

Raise the car so that the underside of the frame can be inspected, and feel along the frame at all junctions between side-members and cross-members; do not take notice of slight unevenness of the metal at these points, as the process of manufacture sometimes causes this; but if there is any definite evidence of buckling, the frame is bent at this point; if no damage is visible, try the angles formed by the junctions of the side-members with the cross-members by means of an angle gauge wherever this can be applied.

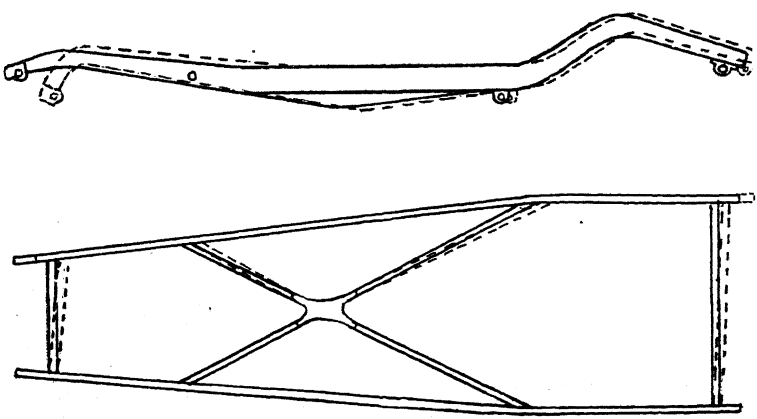


Fig. 6.—EFFECT OF OFFSIDE FRONT IMPACT

The dotted lines indicate the points of distortion that might be discovered.

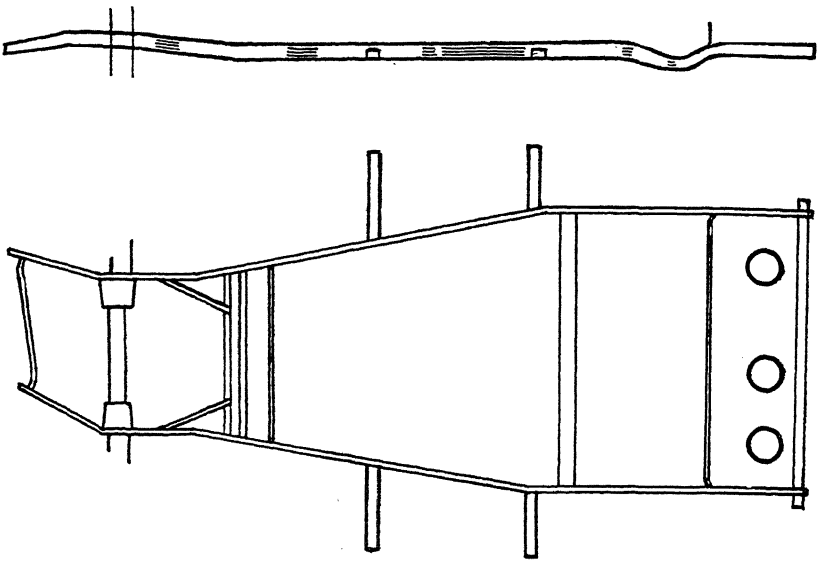


Fig. 7.—EFFECT OF FRONT IMPACT CAUSING ONLY DUMB-IRON DAMAGE

If the result of examination shows that there is no damage behind the dash, it will not be necessary to remove the body to execute the repairs.

It is, in every case of this description, advisable to examine the engine bearers to make sure none of these has been bent or fractured.

Second Example—Impact on Offside Front Dumb-iron

The previous example was given on the assumption that impact occurred on the front wing and wheel; we will now consider what is likely to happen if a similar blow, occurring at about the same part of the car, but just missing the wheel, is received directly on the end of the dumb-irons. In this case there may be no damage to the front axle or the side of the frame, but the whole side-member may be pushed back relative to the rest of the frame, and this will necessitate removal of the body and engine to repair. The simplest test for this, if there is no visible distortion of the frame, is to drop a plumb-line and mark the position of the four extreme corners of the frame on the ground, as previously explained. Then wheel the car away and measure the two diagonals; if these vary by more than $\frac{1}{4}$ in., the side-member has been pushed back; of course, if the dumb-iron itself is bent or broken, the extreme front of the car cannot be used for dropping the plumb-lines, but points may be dropped from the rear end of the front springs.

To Test for Twisted Frame

To test for a twisted frame on a car which is not dismantled may appear somewhat difficult, but if a jack is placed under the centre of the front

axle and the height of the rear ends of the frame is measured from the ground, and the end which is nearer the ground jacked up to equal the other, then measurements taken from the two front ends to the ground should equal each other if there is no twist in the frame (an error of $\frac{1}{8}$ in. is allowable). This test must be made on a reasonably flat floor.

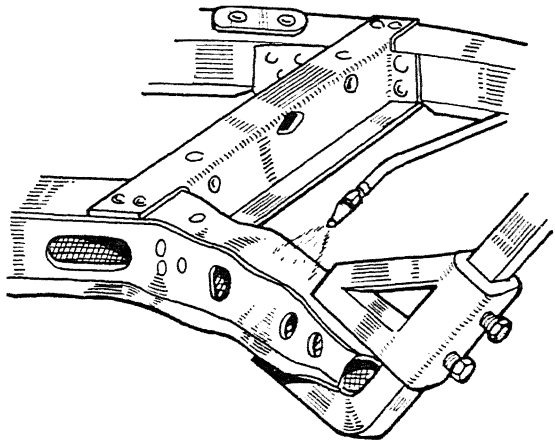


Fig. 8.—Resetting of front dumb-iron

Where the body, wings, and radiator have been removed, the frame can be tested by means of a spirit level applied to parallel pieces of metal placed across the frame as far apart as possible and at right angles to the centre-line of the frame. If the same test is required on a frame which is completely stripped out, the parallel bars can be placed in the same manner and they can be sighted for any twist.

Repairing Crushed-in Frame

When the damage to the frame has been ascertained and the amount of repair decided upon, the question as to whether it is within the capacity of the repairer will depend on the nature of the distortion.

If the frame is crushed in it will be shortened, and this must be corrected as the section is brought back to its original shape. To do this fix some form of expanding jack between cross-members on either side of the damaged part, as shown in Fig. 12, apply pressure, and if the distortion is not too great, the frame will probably be

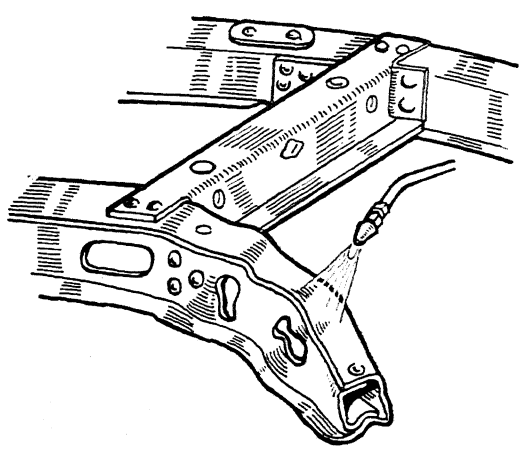


Fig. 9.—Dumb-iron damage, showing points which heat should be applied

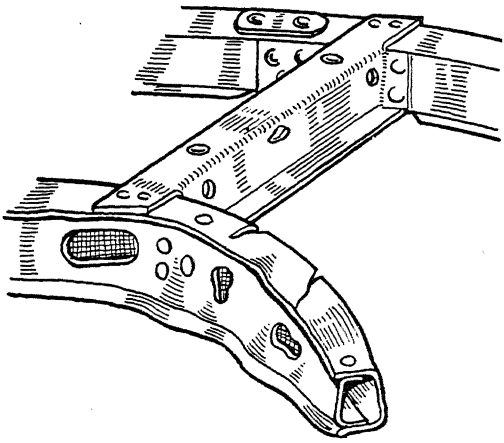


Fig. 10.—DUMB-IRON DAMAGE, SHOWING CRACKS CAUSED BY EXCESS TENSION

stretched back into its correct shape without the use of any heat. In any case, use as little heat as possible, as the application of heat on the thin metal used in the construction of the frame will tend to still further shorten the damaged part and render the frame useless.

If the method suggested is not successful, proceed to cut away a side of the frame section at the damaged part so as to leave the other three sides forming a channel; this will then be more easily dealt with, and a new piece of plate can then be welded in; when this is trimmed off the repair should not be visible. The frame must again be checked after welding, as some distortion will take place.

Welding-in New Sections of Damaged Frame

However badly a frame is damaged, it is now possible to repair by welding-in new sections. These may not be obtainable from the manufacturers and therefore have to be specially made by hand; the point which the repairer has to decide is whether the repair is more economical than the purchase of a new frame.

Where the metal body of the car is riveted to the frame, it is usually possible to repair the frame without removing the body, even when the damage is very considerable or at the rear end of the frame, and this procedure is advisable, as the refitting of these bodies after repair is

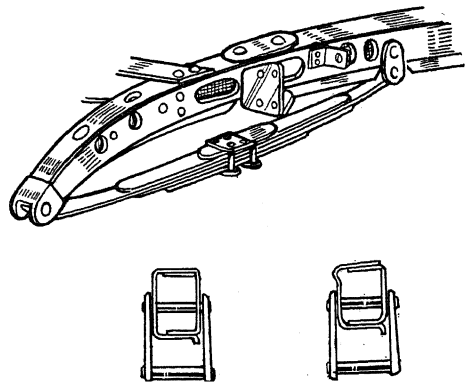


Fig. 11.—DISTORTION OF SIDE-MEMBER SECTION AND RESULTING DISPLACEMENT OF SPRING

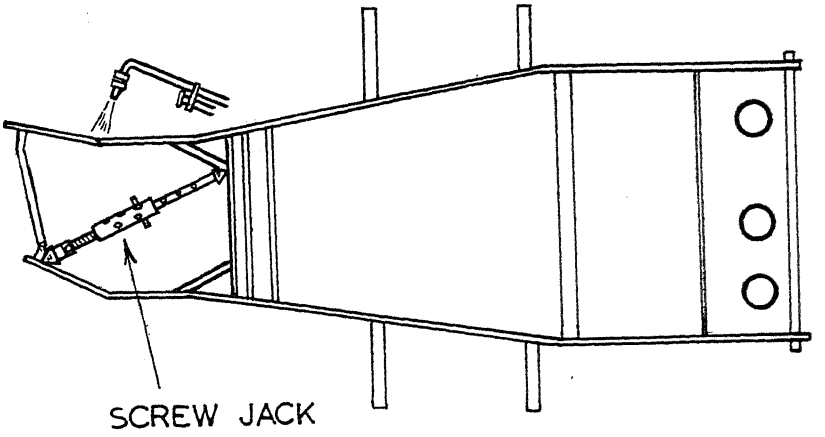


Fig. 12.—METHOD OF REPAIRING CRUSHED-IN FRAME

Showing expanding jack fixed between cross-members on either side of the damaged part. If the distortion is not too great, the frame will probably be stretched back into its correct shape without the use of any heat. In any case, use as little heat as possible.

expensive, and if the straightening work is beyond the scope of the repairer the employment of a specialist will probably prove economical.

When a chassis has been dismantled for repair to an all-welded frame, it is always necessary to examine carefully the original welding, which may have given way as the result of the accident, particularly at the junction of cross-members and side-members, and it may be found that welds which are some distance from a point of impact have been affected.

Methods of Reinforcing Broken Frames

The usual methods employed in reinforcing broken frames are enumerated as follows:

(1) Inside sleeves can be inserted to cover the fractured part and welded in position. This is a most suitable reinforcement for commercial-vehicle frames, doubling, as it does, the original thickness of the frame.

(2) "Boxing in" can be satisfactorily used in many private-car frames. This is carried out on a channel-section member by edge welding a fourth side where necessary so as to form a complete box section. It

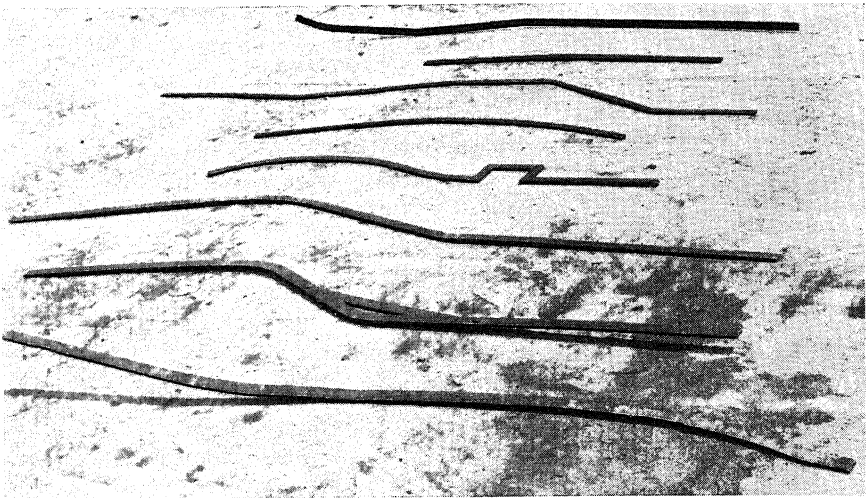


Fig. 13.—STEEL TEMPLATES BENT TO CHECK CONTOUR OF FRAME MEMBERS

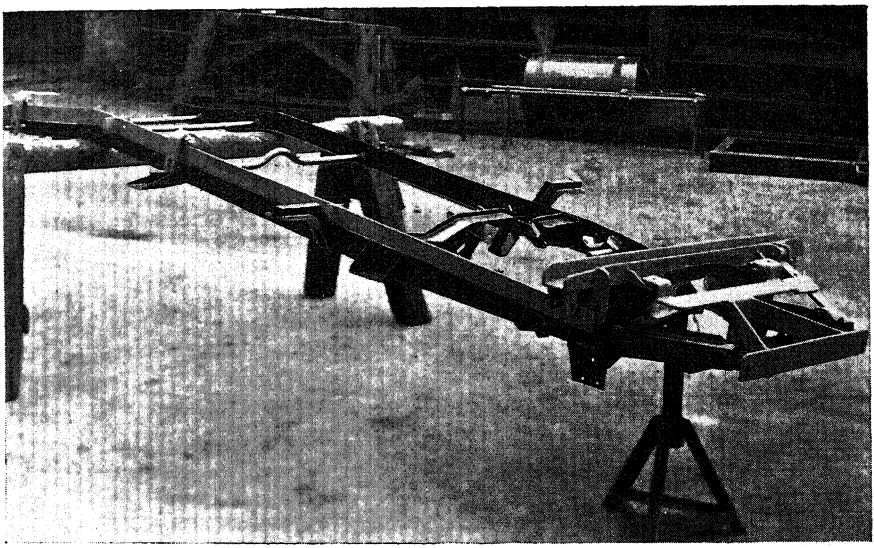


Fig. 14.—MODERN BOX-SECTION CHASSIS FRAME WITH JIG IN POSITION

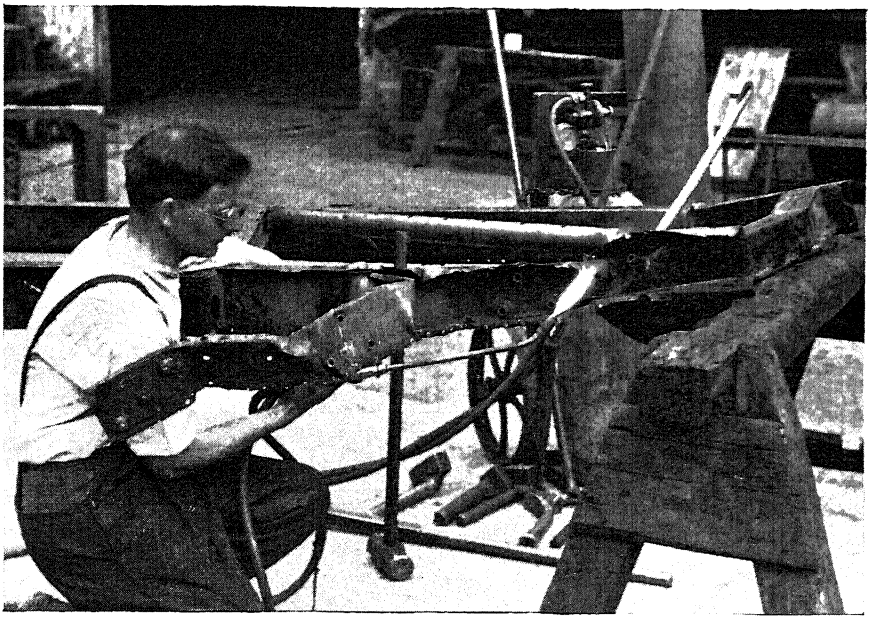


Fig. 15.—CUTTING SIDE OUT OF SECTION OF BADLY DAMAGED BOX FRAME TO SIMPLIFY STRAIGHTENING

The completed job is shown in the next Figure.

may be necessary to drill holes in this reinforcement so that bolts in the original members may be accessible.

(3) Where box-section frames are fractured it is often possible to remove one side of the section, reinforce with an inside plate, and replace the side, thus making an invisible repair.

(4) Where brackets and other fittings make it impossible to use other methods, the bottom flange of a side-member may be reinforced by welding a lip to the flange, thus increasing its width.

Where any of the above methods are used, and in fact where any welding is carried out on a light frame, it is important to remember that distortion will take place, and this must be corrected.

Method of Telling if Frame is bent without Measurement

In many cases of inspected damage to the chassis frames of complete vehicles there are external indications which may be of great assistance. A few of these are mentioned below :

(1) The engine bearer arms should be carefully examined. In order to provide the necessary flexible mountings the engine bearer plates are now frequently of light section and will bend when distortion of the front

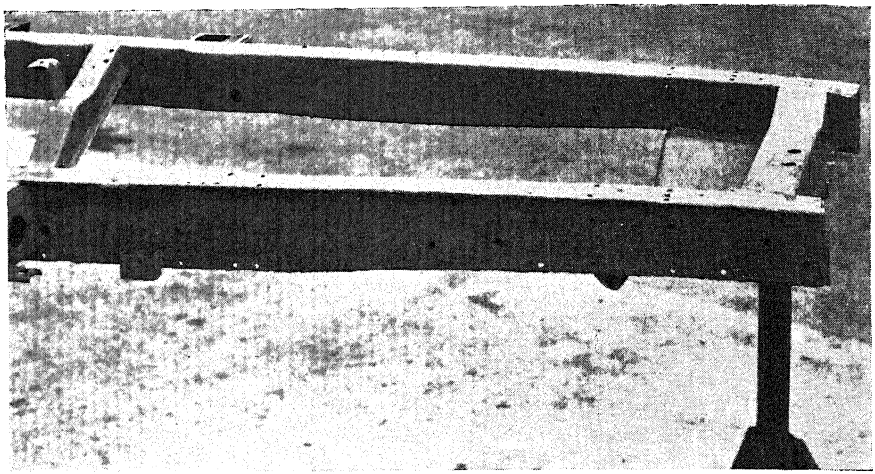


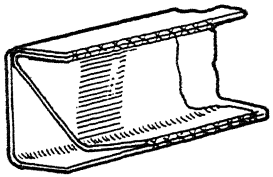
Fig. 16.—BOX SECTION FRAME FROM WHICH SECTION WAS CUT DURING REPAIR
The original damaged frame is illustrated in the previous Figure.

end of the frame takes place. (It should be noted, however, that it may happen that the sudden stopping of the vehicle, due to an accident, will cause the engine to jump forward, but in this case the engine bearers are usually bent equally both sides.)

(2) The position of the steering column where it passes through the bulkhead of the body is frequently a guide to possible frame distortion. If the column is forced over to one side of the hole in the bulkhead the front end of the frame may be bent, but here again it is necessary to be certain that (*a*) the column itself is not bent, or (*b*) the bulkhead is not distorted.

(3) If the starting handle does not register with the dogs on the engine it is again frequently the case that the frame may be bent, but in cases where the engine is mounted on the front cross-member with a heavy bracket, it is possible for the front end of the frame to be considerably out of line although the starting handle engages correctly. This is due, of course, to the fact that the engine is brought round with the chassis frame.

(4) The fit of the bonnet is a most important indication of frame alignment so long as the radiator and bonnet themselves have not been damaged. A gap at the lower end of the rear of the bonnet is often a reliable indication that the frame has sunk immediately under the bulkhead. Also, if one corner of the bonnet at the rear is overlapping the body while there is a gap between the opposite corner at the front and the radiator, this may mean that the front end of the frame is out of square.



CHANNEL REINFORCEMENT

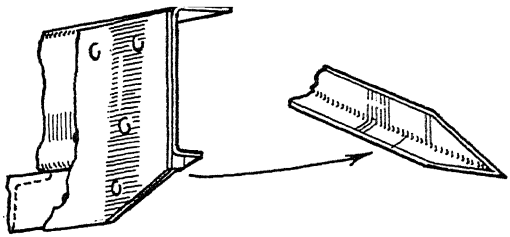


PLATE & ANGLE REINFORCEMENT



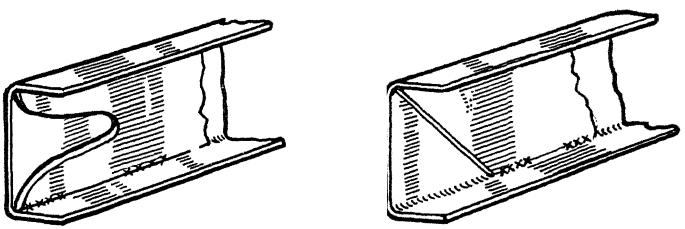


PLATE REINFORCEMENT
SHOWING STAGGERING OF THE STITCH WELDING USED

Fig. 17.—METHODS OF REINFORCING BROKEN FRAMES

EXAMINATION OF INDEPENDENT FRONT-SUSPENSION UNITS FOR SUSPECTED ACCIDENTAL DAMAGE

The Buick Type of Suspension

This group includes many well-known makes, including Packard, Daimler, and Oldsmobile.

This method of suspension employs coil springs, and from the point of view of suspected accidental damage this system has two distinctive features :

(1) That the offside and nearside assemblies are mounted quite independently (usually on a very heavy chassis frame front cross-member) and are connected only by the necessary steering connections. As the latter are normally lighter in section than any of the suspension parts, it follows, therefore, that it is sometimes possible for one of the suspension units to receive a very severe blow indeed without affecting the other side.

(2) The upper control arm of the suspension mechanism is usually made integrally with a powerful shock absorber, which thus controls the whole vertical movement of the wheels. It is therefore essential that these shock absorbers should be in proper working condition, and a bent spindle which may result in partial seizing of the shock absorber is sufficient to hold down that side of the car ; this, of course, can be checked by releasing the shock absorber on that particular side.

A frequent result of damage to this type of suspension is that a blow on the wheel is transmitted through the lower control arms to the front cross-member, which often becomes buckled or torn at the point where the control arms are mounted.

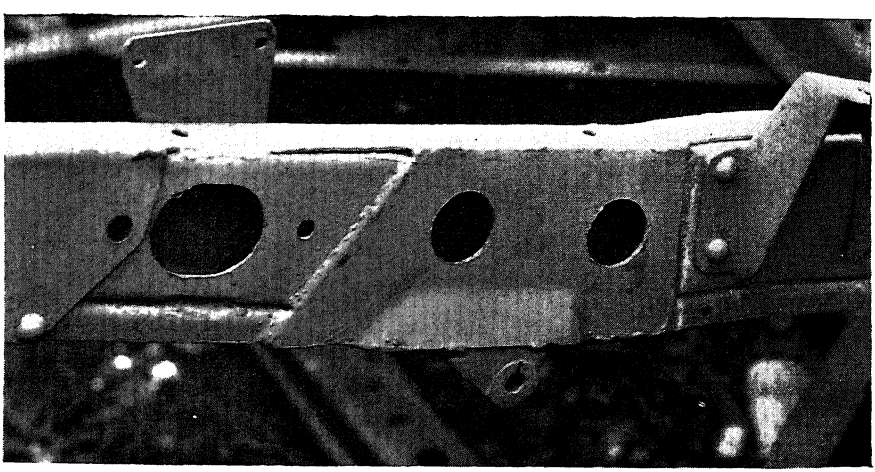


Fig 18.—SPECIAL METHOD OF REINFORCING BROKEN SIDE-MEMBER ABOVE SPRING BRACKET

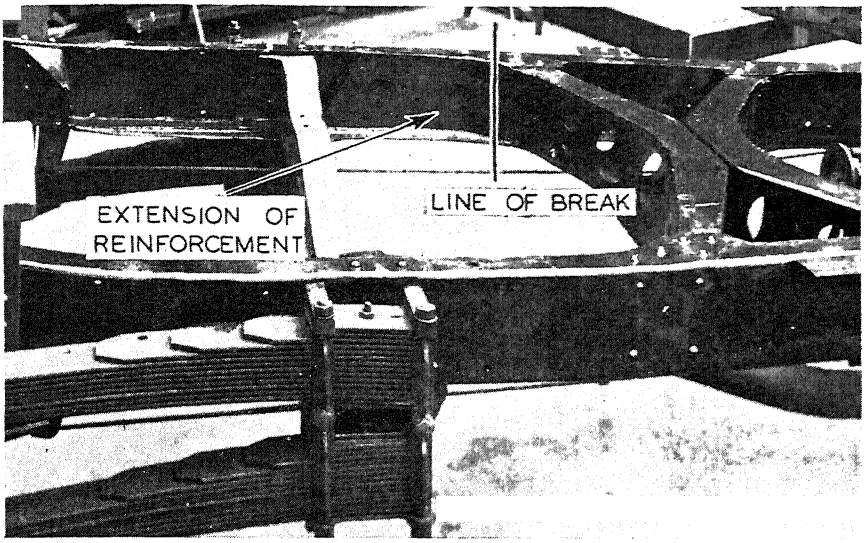


Fig. 19.—METHOD OF REINFORCING BROKEN EXISTING FRAME BY EXTENDING "BOXING-IN" AND BY WIDENING LOWER FLANGE OF MEMBER

Tracking and checking the splay of the wheels provides a good method of determining whether the suspension has suffered damage, but care must be taken to see that the car is loaded with the correct weight on the front end. If the wings and radiator are removed, for example, it is obvious that the splay of the wheels cannot be accurately determined.

In a case where one particular part of the mechanism is known to be bent, it is essential that all other parts on that side should be dismantled and carefully checked either with jigs or with manufacturer's drawings. Bent parts of the suspension mechanism may generally be straightened, but if heat is used the parts should be re-heat-treated after resetting. On no account should broken parts be welded unless they are units which have been originally constructed by welding, and even then discretion should be used.

The Vauxhall Type of Suspension

Similar types to the Vauxhall suspension are the Opel and Chevrolet.

Many of the foregoing remarks apply to this type of suspension, but there are one or two important distinctions when checking for suspected damage.

(1) The offside and nearside assemblies are in this case mounted on a rigid beam, often of tubular section (on a steel pressing in the case of the Chevrolet), which is attached to the chassis frame and forms the front cross-member of the frame. The ends of this beam are similar to the eye

ends of an ordinary front axle, and the assemblies are mounted with a pivot pin in the usual manner.

Whether the car is hit on the front of the frame or on a wheel, this beam then, is very likely to suffer damage. It should be dismantled and checked with jigs or drawings if malalignment is suspected. Provided the work is carefully carried out, these beams may often be reset.

(2) In this type of suspension it is often extremely difficult to determine by a superficial examination whether the actual suspension parts (some of which are enclosed) are bent, and if wheel alignment appears to be incorrect it is better to dismantle and check each part independently, and as these parts are often, of necessity, of irregular design, the proper jigs should be employed.

The Citroën Type of Suspension

This employs the torsion-bar method and (in the case of the Citroën) in conjunction with the front-wheel drive.

When checking for suspected damage on this type of car it is important to note that some parts of the suspension are mounted as far back as the steel pressing at the rear of the engine, and it frequently happens that these mountings are distorted in an accident, and this may be readily seen.

Distortion of the cradle-type front cross-member of these cars will also sometimes give an indication of suspension damage.

The Hillman and Humber Type of Suspension

The Studebaker and Standard are also similar to the Hillman and Humber suspension in many respects.

This method employs a transverse spring, in conjunction with control arms or a second transverse spring. Care should be taken, when checking for damage on this type of car, to see whether the spring leaves are bent or the eyes unrolled. It is also possible that the springs may move bodily as the result of a severe impact, and this cannot always be seen without dismantling. Here, again, the mounting of the suspension units on the front cross-member of the frame is most important, and signs of damage on the member should give an indication as to suspension damage.

In general, the following points may be of assistance when examining a case of suspected damage to front-suspension units.

(1) The track and camber of the wheels should always first be checked.

(2) The points where the suspension parts are attached to the frame should be carefully examined for signs of buckling or fracture.

(3) Where alignment of the suspension is determined by brackets or shock absorbers mounted on flat faces of the frame or front cross-member, these faces should be checked and compared with straight-edges.

(4) In some cases measurements can be taken from a fixed point on the side-member to the suspension units, but it must be remembered that

tolerances are very small indeed on independent suspension units, and generally only fairly large errors can be found in this way.

(5) It should be mentioned that tyres play a very large part in the correct action of the suspension, and worn tyres or incorrect tyre pressures have been found to account for what appeared at first sight to be accidental damage. It is also very necessary to see that no undue wear is present in any moving parts, and that steering connections in particular are in proper condition.

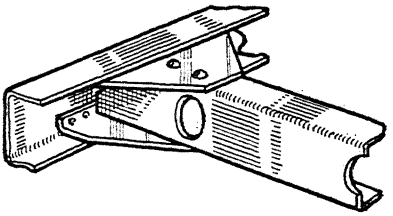


Fig. 20.—REINFORCEMENT OF CROSS-MEMBER BY MEANS OF TWO GUSSETS

(6) It is frequently of great assistance, when both the chassis frame and suspension units have been repaired, to assemble these parts together and check wheelbase length and wheel alignment before the final assembly of the car is proceeded with. This applies particularly to those cars in which the suspension, assembly forms the front cross-member of the chassis frame, as slight distortion to both the frame and suspension units can sometimes be caused during assembly.

(7) The point should be noted that, with a very large number of independent suspension units, provision is made, either by an eccentric bush or other means, for final accurate adjustment of wheel alignment, and where very small errors are detected these can often be overcome in this way. Provision is also sometimes made for adjusting the height of the suspension, and this, as with all other alignment adjustments, should be carried out on the completely assembled car.

(8) It will be noted that with the majority of types of independent springing the question of wheel alignment is very closely linked with the chassis frame front cross-member, and although damage to the one does not necessarily imply that the other has suffered, it is important to regard the two assemblies, that is, the front cross-member and the suspension mechanism, as one whole unit which, when complete, determines the correct front-wheel alignment of the car.

(9) In almost all methods which are used in independent suspension it is safe to say that the shock absorber plays a most important part in the control of the very flexible springing obtained, and, after an impact, it is necessary to see that these essential units are functioning correctly, otherwise trouble may be experienced even though no suspension parts are bent and wheel alignment may be correct.

WORKING TOLERANCES AND ALLOWABLE LIMITS OF ERROR ON CHASSIS FRAMES

It frequently happens that small errors which may be found in a chassis frame after an accident give rise to the very important question

of tolerances, and sometimes it may be necessary to obtain the expert opinion of a specialist as to whether the errors should be rectified.

Centre Line at Rear of Engine

To take one or two familiar examples. An error of $\frac{3}{16}$ in. (not in itself a large discrepancy) in the centre line of the chassis frame at the rear of the engine will mean that the propeller shaft will be double the amount, i.e. $\frac{3}{8}$ in., nearer to one side-member than to the other, which may be sufficient to cause the propeller shaft to hit an obstruction on the frame when the car is in motion.

Length of Wheelbase

On the other hand, an error of $\frac{1}{4}$ in. in the length of the wheelbase may be due to an accumulation of small original errors in the chassis frame and axle assembly, and, provided that wheel alignment is within limits, this $\frac{1}{4}$ in. error in the wheelbase may often be ignored.

Diagonal Measurements of Frame

For the same reason, a difference of $\frac{3}{16}$ in. between the diagonal measurements of the frame (inasmuch as the frame alignment is only very slightly affected by this discrepancy), can be allowed.

Independently Sprung Chassis

There are occasions, however, when the rectification of a small error is essential. For example, the flat faces on the front cross-member of an independently sprung chassis which carry the upper control arms of the suspension must be correct to within at least $\frac{1}{16}$ in., as a small error here will be greatly magnified at the wheels.

Rear Spring Bracket

Again, supposing a spring bracket at the front end of the rear spring is twisted under, owing to a blow on a rear wheel, it may necessitate extensive dismantling and removal of the body to reset the bracket if this is inaccessible, but the work should certainly be carried out, otherwise trouble may be experienced with the rear spring.

As in all checking after accidental damage, this question of allowable limits is of the greatest importance, and it frequently needs considerable experience to decide whether a very small error should be corrected or not.

It should be remembered that a car owner may exercise his right to have the car examined by the manufacturers after repairs have been carried out, and although an error which has been passed by the repairer may in no way affect the performance or assembly of the vehicle, it is obvious that the manufacturers cannot be expected to pass something which is wrong. Any error which is found should have the closest consideration before deciding whether to repair or not. As a general rule, it may be said that any discrepancy which is sufficient to cause malalignment of the wheels must be corrected, and this point cannot be too strongly stressed.

Always Check Wheel Centres after Repairing a Damaged Car

When a damaged car is reassembled after repair, it is of the utmost importance that the wheel centres are correct, and these should always be tested before finally delivering the car.

If they are not correct, the trouble may not lie with the frame. More frequently it is due to the axles not being correctly mounted on the car. There is usually a certain amount of clearance in the axle bed where the locating spigot bolt (which bolts the spring together) is fitted, and this allows the axle to be mounted slightly out of square. It is therefore advisable to look for this trouble before further checking.

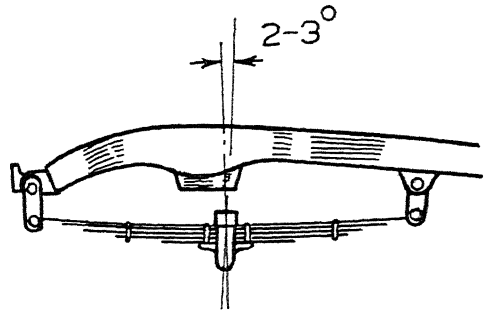


Fig. 21.—APPROXIMATE ANGLE AT WHICH AXLE PIVOT PIN SHOULD LIE WHEN VIEWED FROM SIDE OF CAR

When Reassembling, mount Springs on Frame before Axle is Fitted

Some repairers make a practice of bolting the springs to the axles before mounting to the chassis ; this is wrong, as the spring clips do not locate the springs correctly. They should, therefore, be mounted on the frame before the axle is fitted.

It sometimes happens that when a car is completed, the road performance is not satisfactory owing to some form of steering trouble ; the car may drift towards one side of the road or wheel wobble may develop.

Drifting of Car due to Front-axle Twist

In over 90 per cent. of these cases the trouble is finally traced to the front axle, drifting of the car being usually due to one end of the axle being twisted relative to the other, and front-wheel wobble is the result of wrong assembling of the axle bed on springs.

In Fig. 21 is shown the approximate angle at which the axle pivot pin should lie when viewed from the side of the car. This varies slightly, owing to various reasons, but an extremely small difference in this angle will start or cure wheel wobble, and it is a case of trial and error to determine the exact packing necessary between the springs and the axle bed.

Nickel-steel Frames require Special Treatment

The majority of popular-car chassis frames are in mild steel. Some manufacturers, however, use a nickel-steel, and care should be taken to examine the damaged portion of the various members for flaws and incipient cracks. When any doubt exists it is advisable to send the damaged frame to a firm who specialise in this work.

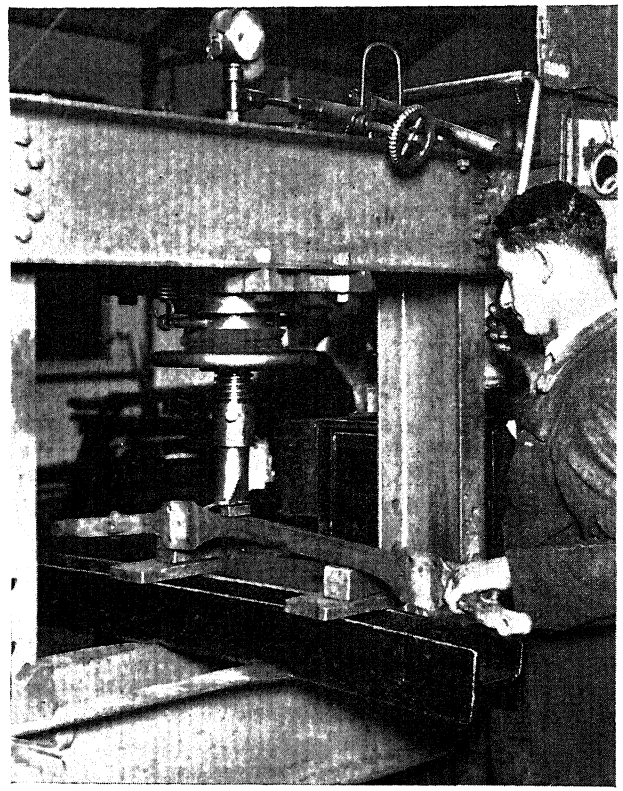


Fig. 22.—STRAIGHTENING BENT FRONT AXLE BEAM UNDER HYDRAULIC PRESS

FRONT AXLE AND FITTINGS

In a very large number of cases of accidental damage to cars, the front axle is subjected to abnormal stress, and even when no impact occurs the sudden application of the powerful front-wheel brakes which are fitted to modern cars will tend to twist the ends of the axle, particularly if they are of I-section. It is therefore imperative that examination of the axle is made a special feature of car checking. Unfortunately it is not possible to test this component accurately while it is attached to the car, but if the spring clips are disconnected and the front of the car jacked up, the axle may be wheeled from under the car if the steering and brake fittings are first disconnected. If a cursory examination shows that the axle beam is bent, the axle must be completely stripped and the beam straightened or replaced by a new one.

The swivel axles, king-pins, and brake drums must all be tested in a lathe, as it is quite usual for some of these parts to be damaged if the beam is bent. It is not advisable to have the stub axles or steering arms straightened; they should be replaced with new ones if damaged.

Checking for Bent Axle Beam

When there is no obvious damage to the beam, the complete axle should be packed up or held in a vice in such a manner that one of the spring platforms is horizontal; this should be set by means of a spirit-

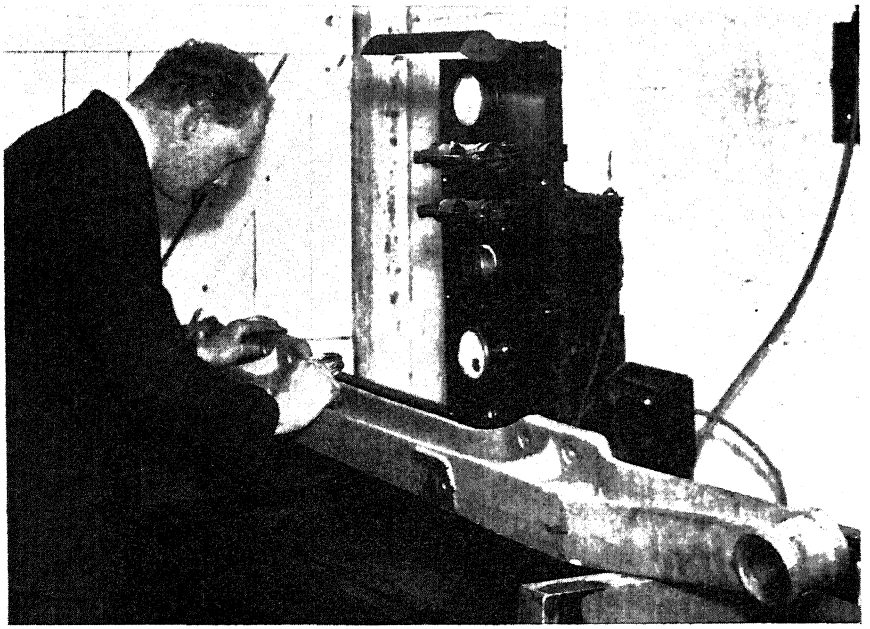


Fig. 23.—EXAMINING FRONT AXLE IN MAGNETIC TESTING MACHINE FOR POSSIBLE FLAWS

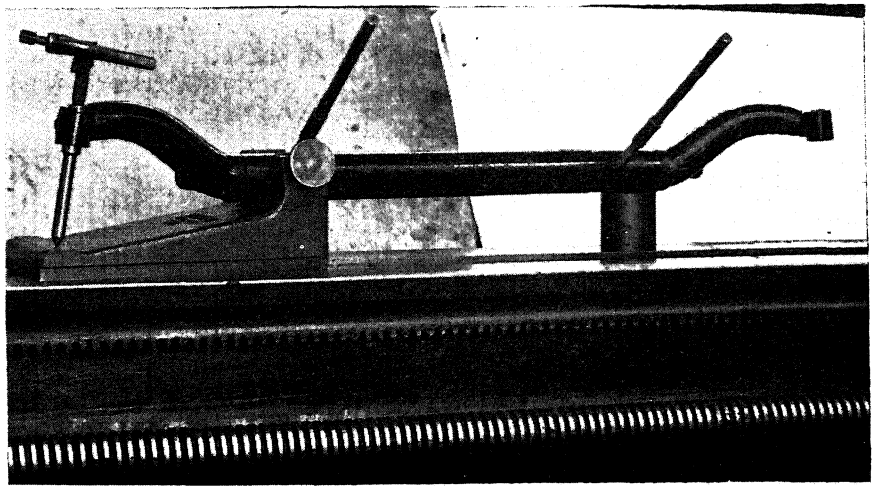


Fig. 24.—TESTING ACCURACY OF FRONT AXLE BY MEANS OF SPECIAL GAUGING JIG

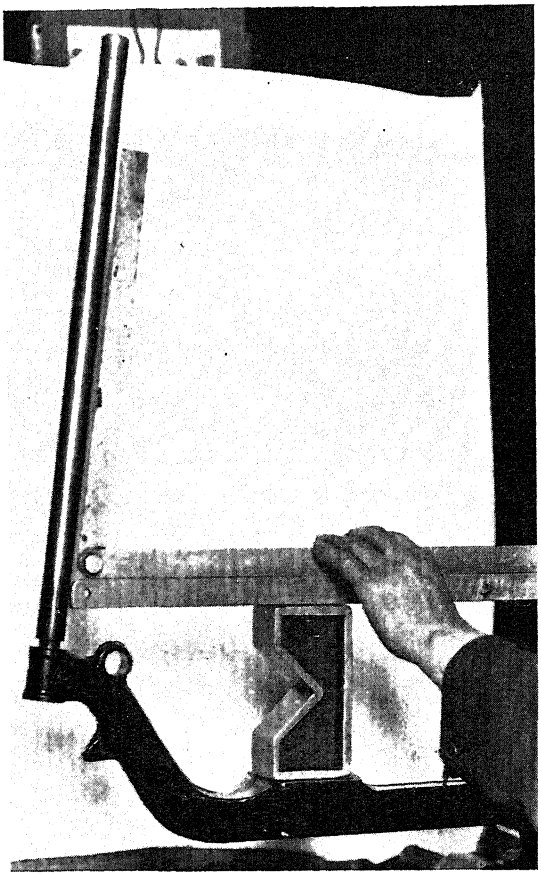


Fig. 25.—CHECKING ANGLE OF KING-PIN BEARING ON FRONT AXLE

level, which should then be placed on the other platform to check whether that also is horizontal; if it is not, the axle beam is bent and the axle must be stripped.

If the two platforms are correct, the spirit-level may be placed on top of one of the king-pins, first in line with the centre-line of the beam and secondly at right angles to it, and the amount the bead is out of centre in the spirit-level should be noted and compared with similar tests made on the other king-pin; if each king-pin gives similar readings, there is no twist in the axle, and the only other check necessary will be to stretch a thin string from the centres of the two king-pins and try with a square off each platform to see whether the line of the string runs through the centres of the platforms. If this is correct, the axle may be passed, and there should be no necessity to dismantle it.

Straightening Front Axle

When dealing with a bent front-axle beam, it is of the utmost importance to decide whether it will be possible to straighten it without the application of heat, for if any heating is necessary the axle will usually require to be re-heat-treated after straightening to restore inherent properties. As a general rule, it is safe to straighten cold if the bending has been of such a nature that the metal has not been stretched to any extent. It is good practice to examine the bent portions of an axle by means of a magnetic tester, which will immediately show up any incipient cracks or flaws which may exist.

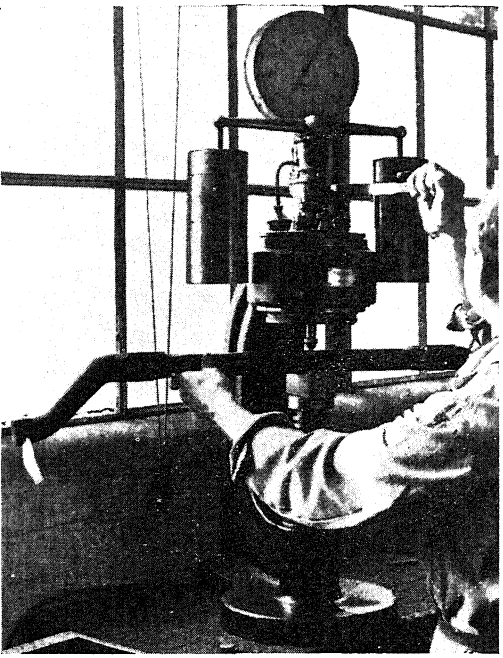


Fig. 26.—TAKING BRINELL TEST ON FRONT AXLE

This test is taken before and after repair when reheat treatment is necessary.

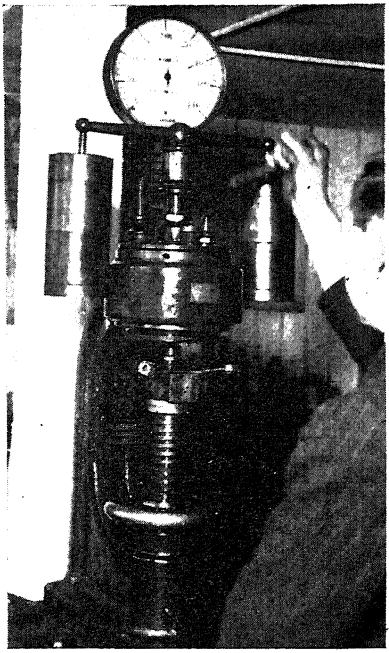


Fig. 27.—BRINELL TEST OF STEERING CONNECTING ARM

Testing Axle Beam for Accuracy

To test a stripped axle beam for accuracy, the beam should be held in a suitable vice and a straight-edge placed on the two spring platforms parallel to the centre-line of the beam ; this will show whether they are both in one plane. If this test is satisfactory, two straight-edges, or parallel strips, should then be rested on the platforms at right angles to the centre-line of the beam, and by standing some distance from one end of the axle, it will be possible to sight both of the top edges of the strips and to see at once whether there is any twist between the spring platforms.

A parallel rod about 18 in. long should be placed in each of the king-pin bearings at the ends of the beam and sighted in a similar manner to see if there is any twist relative to each other, and if the axle is a reversible one, they should also be sighted against a square placed across a spring platform at right angles to the centre-line of the beam.

An angle gauge should then be set to the correct angle given by the manufacturers for the particular axle under examination, and this angle should be tested from parallel packing-strips placed on the spring platforms. This angle should be correct within $\frac{1}{16}$ in. (which represents about

$\frac{1}{4}°$) as it governs the angle which the plane of the front wheel makes with the road.

The only other test necessary is to stretch a thin string between the centres of the king-pin bearing holes and see that the centres of the spring platforms are in the same line.

A point which frequently arises when the axle or steering connections are badly bent in an accident, is how to straighten these parts sufficiently to enable the car to be towed to a garage, and this may be overcome by heating the damaged parts and roughly straightening them on the car; if this is done, the steering parts must not be used again but must be replaced by new ones.

After Heat Treatment

When the damaged parts are to be straightened and re-heat-treated, a Brinell test should be taken before any work is started on them and again when they are finished, so as to check the heat-treatment. The parts should also be carefully checked for accuracy, as heat-treatment affects this in many cases.

REAR AXLE

The rear axle is another component which frequently suffers damage when a car is involved in an accident. This damage is often overlooked unless it is quite obvious; in fact, in many cases, even when a car has been badly smashed up and had to be completely stripped and the frame straightened or replaced, there has been no suspicion on the part of the repairer that there could be anything wrong with the rear axle, and the car has been finished ready for the road before anything wrong was suspected. Even then, the repairer or owner (knowing the frame to have been seriously damaged) concludes that this has been badly repaired. The writer is frequently called upon to inspect cases of this nature, and often finds that the car has again been stripped to locate the trouble, whereas a few minutes' intelligent checking would have pointed to rear-axle defect.

Checking Axle without removing from Car

The complete axle can easily be checked without being removed from the car by first jacking up and testing the wheels. If these do not run out of truth and the axle shafts appear to be perfectly free when turned by means of the wheels, the jack can be removed after the wheels have been turned so that each tyre valve is towards the front of the car and about the same height from the ground as the centre of the wheel. The measurement between the wheels at the valves should now be taken with a track tester or suitably bent rod, after this the car should be wheeled along until the two tyre valves are at the back of the car and at the height of the wheel centre from the ground, and the measurement between the wheels at the

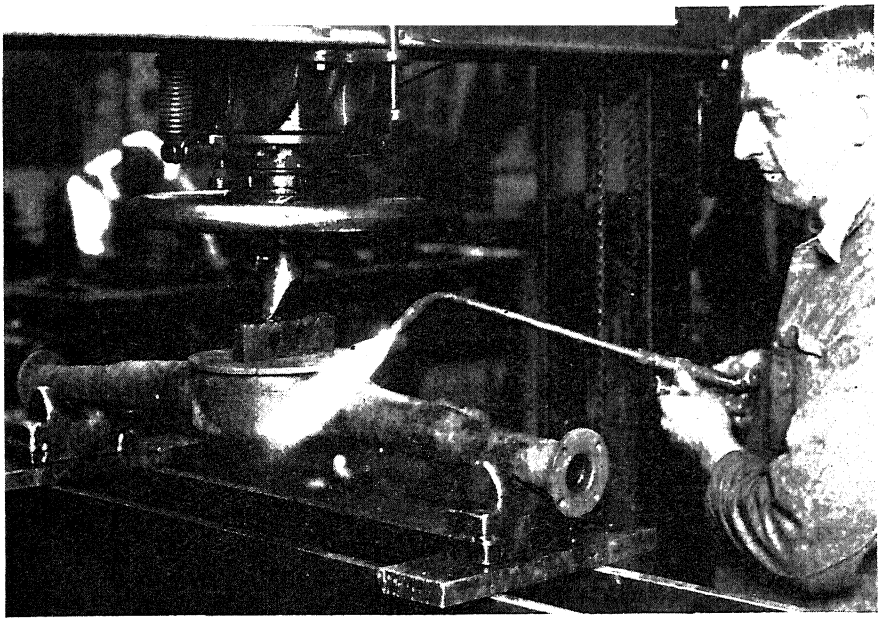


Fig. 28.—STRAIGHTENING BENT REAR AXLE CASING BY HYDRAULIC PRESS WHILE HEAT IS APPLIED

valves again taken. If this is the same as when the valves were in the front position, the axle is correct in the vertical plane (the valves are used in making these checks to ensure that the same points of the wheels are used both at the front and rear, and this makes the test accurate even if the wheels are not perfectly true).

To check in the horizontal plane, set one of the wheels vertical by means of a plumb-line. The line may be dropped from the wing and measurements taken from the rim to the line at top and bottom of the wheel; if these measurements are not equal, the axle can be suitably jacked up until they are. The other wheel should then be tested with a plumb-line and should be vertical without any alteration of the jack.

If the axle passes these tests, it is correct, otherwise it must be taken down and completely stripped out.

Straightening Axle Casing

The axle casing should then be set up in a lathe and, by means of a scribing block, the point at which the bending has taken place, located. If the casing is from a light car and the bending not too serious, it should be possible to straighten in the lathe by suitably packing under the bent part so that a lever can be used, while slight heat is applied, to spring the axle casing true. When straight, the faces to which the brake

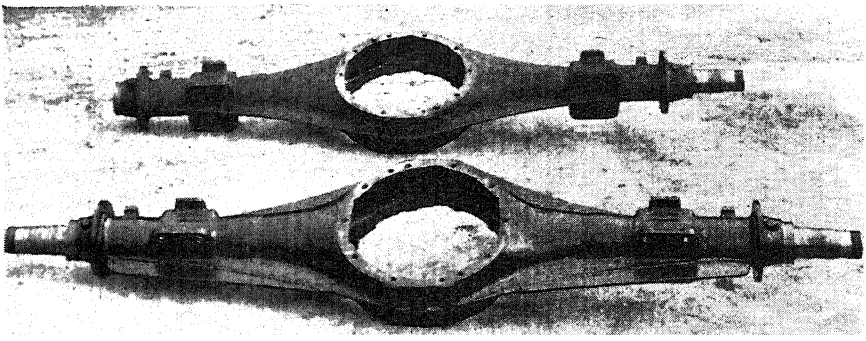


Fig. 29.—METHOD OF REINFORCING REAR AXLE CASING TO STAND EXTRA LOADING

assemblies are bolted must be carefully checked, and a slight skim taken off them in a lathe if required.

If the casing is badly bent, it will be necessary to straighten under a press, and it may be advisable to employ a specialist for the repair.

Torque Tube, Propeller and Axle Shafts

The torque tube, propeller shaft, and half-axle shafts should also be tested in a lathe, as well as the brake drums and plates.

Wheels

Pressed-steel and easy-clean wheels are usually difficult to repair with the equipment at the disposal of the average repairer, as they require to be clamped to special fittings and straightened by means of a press. It is usually possible for specialist repairers to repair them economically.

Wire wheels should be examined for loose or broken spokes, and when these require replacing or tightening, the wheel should be mounted in position on the finished axle so that the truing up is accurate. The correct tension can be regulated by the sound given by the spokes when tapped with a piece of steel.

ACCIDENTAL AND FROST DAMAGE TO ENGINES

This article would be not complete without reference to engine damage, which frequently occurs when a car is involved in an accident. Apart from this, the car is usually insured against damage due to frost, by which the engine and radiator are the principal components affected.

Accidental Damage

Accidental damage to the engine usually results in a part of the main casting being broken, such as the fan-bracket support, engine-bearer

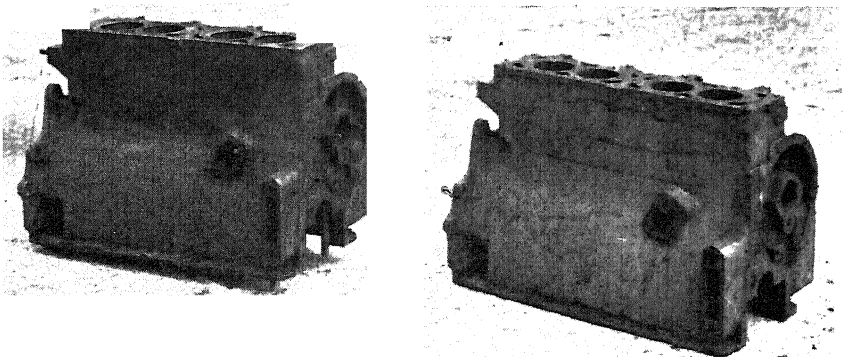


Fig. 30.—REPAIR OF CRACKED WATER JACKET OF CYLINDER BY PATENT COLD PROCESS
This repair can often be made without dismantling the engine.

supports, dynamo bracket, etc. It is possible to repair many of these breakages without completely stripping the engine, and this, of course, results in a very considerable saving in the cost of repair, quite apart from the fact that an engine which has done a considerable amount of work usually develops more noise after it has been taken to pieces and re-assembled without undergoing complete overhaul.

Frost Damage

As regards frost damage, this usually results in fracture of some part of the water jacket. If this is repaired by welding, it will, in most cases, necessitate reboring and the fitting of new pistons as well as the refitting of all bearings, and this will make the repair an expensive one. On the other hand, there are now available processes for repairing cracked water jackets which in many cases

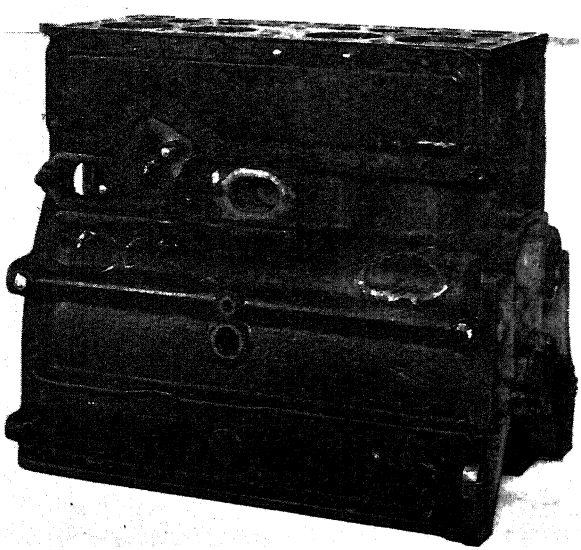


Fig. 31.—BROKEN PIECE ELECTRICALLY WELDED IN CRANKCASE

obviate the necessity of stripping the engine, thereby saving considerable time and money.

The repairer should, therefore, satisfy himself or obtain the advice of a specialist regarding the possibility of repairing the engine without completely dismantling before he proceeds with the work.

HOW TO LOCATE AND REMEDY CAR NOISES

By C. W. G. TAYLOR

ALTHOUGH it is usually a simple matter to eliminate a noise once the cause has been traced, it is often very difficult indeed to locate the defect causing the noise, even when the position from which it originates is known fairly accurately. Some of the more troublesome causes of noise are considered in detail below, and similar procedure to that recommended in these selected cases may be applied to advantage in locating other similar defects.

Doors and Windows

Rattle from the door of a car can be due to one or a combination of three defects :

(1) Glass may rattle in frames.

(2) Door may rattle bodily.

(3) The window-winding mechanism (housed inside the lower part of the door) may rattle.

The first step in tracing the fault is to close all windows tightly, and then, one by one, open each door and shake it thoroughly, and also press the glass, to detect any looseness.

If the noise is heard while the door is being shaken with the window closed and there is no sign of glass looseness, it indicates that the window-winding mechanism is the cause of the trouble, for with the door open, any knocking against the door frame is eliminated.

If the rattle is heard with the window open or partly open, but not when closed, it indicates that the glass is loose in the runners. In the event of the door not rattling when shaken either with the window open or closed, it is evident that the noise heard only when the car is on the road must be due to the door rattling bodily.

Remedy for Glass Rattling in Frame

The most usual cause of this trouble is that the rubber strips at the sides of the window become worn. These are not visible. The inside window frame must be removed by taking out the screws. The rubber strips or slides can then be seen and inspected. Sometimes a satisfactory remedy can be effected by reversing the strips from the two sides and

refitting upside down. If, however, the wear is general, and additional packing is not likely to be satisfactory, a new strip, which can be obtained from any body-builder, should be inserted.

Remedy for Doors which Rattle Bodily

The door rattle can be due either to worn-down rubber stoppers or to the door having dropped a little at its hinges. In either case the cause can readily be ascertained by inspection.

The hinges should be checked over first, as the screws sometimes work loose, causing play between the door and the frame. If this is found to be the case, the loose screws should be taken out and a little cotton-wool inserted before replacing the screws, otherwise they may very soon work loose again.

In the case of the rubbers, these are fitted just above and just below the lock catch, and are so fitted that when the door lock is on its first catch they are just touching the door, and are compressed when the door is fully shut.

If the rubber stops are found to have become permanently compressed or distorted, they can be removed and packed out to the extent necessary to provide the required pressure against the door to hold it firmly in position.

Alternatively, it may be found that the door catch requires adjustment. The catch which engages with the bolt is seldom the rigid fixture it often appears. It will usually be found that by loosening the screws which appear to secure the catch to the car the catch can be moved back as much as half an inch. This adjustment is expressly provided to restore pressure against the rubber stops after they have lost some of their elasticity.

Conversely, whenever new rubber stops are fitted to a car door, the position of the catch should be checked over and the catch moved to its most forward position, so that the rubbers are not subjected to excessive pressure, which would cause early distortion and necessitate slamming the door to engage the catch.

Defective Window-winding Mechanism

First remove the inside door handle and the window-winding handle. This is done by tapping out the small pins that hold the handles on their shafts. To locate these pins it is necessary to push the round metal casing, which is fitted behind the handle, towards the upholstery. This reveals the shaft and the pins. The panel board on the inside of the door can then easily be removed after taking out a few screws. The winding mechanism can then be seen. This mechanism is subject to two defects which can cause a rattle. The screws, securing the plate on which the mechanism is mounted, tend to work loose. This can be remedied very simply by tightening the screws which hold the plate.

The runners which travel in the slide at the bottom of the glass develop play with wear. In this case the gap in the slide should be closed up until the runners have side movement only, i.e. no vertical play and no movement at right angles to the glass. Before replacing the panel, the rollers, their spindles, and the slide should be liberally greased.

Squeak from Front of Bonnet

No fewer than seven different components can cause the same kind of noise, i.e. a squeak, at the upper part of the front of the car :

(1) Loose radiator grille.
(2) Loose radius rods.
(3) Worn bonnet webbing.
(4) Loose radiator supports.
(5) Distributor shaft running dry.
(6) Fan shaft running dry.
(7) Generator armature running dry.

Fortunately these can readily be divided into two groups, thus narrowing down the investigation. The first four mentioned above are *not* heard with the engine running while the car is stationary, whereas the last three *are* heard. No. 1, loose radiator grille, is a borderline case. Sometimes a squeak due to looseness here can be heard with the engine running and the car stationary, and this should be taken into account. Occasionally vibration can be detected with the finger tips although the squeak itself cannot be heard.

If the squeak is *not* heard with the engine running while the car is stationary the next step is to examine the radiator grille for looseness. If this is not loose, stand in front of the car and grip the radiator firmly. Now force the radiator first backwards and forwards. If this produces the squeak or lateral play is detected, it means that the radius rods are responsible. Now apply side-to-side movement. If the radiator is felt to yield, it indicates that the webbing at the front of the bonnet is defective.

In order to check the radiator supports it is necessary to lift the bonnet and grip the radiator (as distinct from its casing) and apply side-to-side movement, or in other words, attempt to rock the radiator.

Alternatively, if in the car concerned the springs or rubber blocks on which the radiator stands are easily accessible, these should be inspected to see if there is any play between the chassis frame and the bottom of the radiator.

Had the squeak been heard with the engine running it would have been a very simple matter to trace which of the remaining possible defects was the cause, for with the bonnet raised there should be little difficulty in distinguishing whether the squeak came from the distributor shaft, fan shaft, or the armature housing.

Remedy for Loose Radiator Grille

The clips on each side of the grille should be opened out to exert more pressure on the grille.

Loose Radius Rods

Unclip and raise the bonnet. The radius rods support the radiator and its casing. The rods extend from the rear of the radiator to the dashboard, and are held in position by brackets at each end through which the rods pass. The rods are threaded at each end and are fitted with nuts which pull up against the brackets and so hold the rods in tension. One or more of these nuts may have worked loose, allowing the rod to move in its brackets, thus producing the squeak. The trouble is remedied simply by tightening the nuts until the rods are held firmly against their brackets.

Defective Bonnet Webbing

Webbing is used at each end of the bonnet, at its junction with the radiator and the front of body, to prevent the bonnet from rubbing on the other surfaces. In course of time this webbing wears, and in places may be found to have worn through, thus allowing the two metal surfaces to rub together. Worn webbing at the rear end of bonnet can be detected only by close inspection. Nothing short of renewing defective webbing will eliminate the squeak.

Loose Radiator Supports

If spring mounted, remove split-pin from castle nut on holding-down bolt and tighten two or three turns until any further movement would compress the spring. On no account should the spring be fully compressed, as its purpose is to prevent road shock from being transmitted to the radiator.

In the case of rubber blocks, if these have lost their resilience, they should be removed and replaced by new ones. Insertion of additional packing is not recommended.

Distributor, Fan, and Generator

In each of these three cases the squeak is due to lack of lubrication. In the case of the shaft running through the centre of the distributor housing, the oil cap may be difficult to find as it is usually at the extreme bottom of the housing, and is protected by a spring-loaded dust cap. This cap has to be pulled back before the oil hole is visible. The cam on the distributor shaft and the pin holding the contact breaker arm should both be inspected. If these are dry they will produce squeaks. Use only light machine oil for lubricating these components. It should be applied very sparingly indeed. All the above remarks in connection with lubricating the distributor also apply to the generator.

The fan in most cases can be greased with the grease-gun supplied with the car.

Squeak from below Front of Car

In this case a different method is necessary as there are four possible causes, two of which involve a considerable amount of work. Hence

every care should be taken to eliminate the possibility of the defect being due to one of the others before investigating the two difficult defects. The following group is therefore given in order of increasing difficulty with a view to avoiding waste of time in locating and remedying the cause of the trouble.

(1) Front bumpers loose on bracket.
(2) Worn shock-absorber bushes.
(3) Defective springs.
(4) Road-wheel bearings.

It is worth while running the engine with the car stationary. Although the squeak is not likely to be reproduced it is possible that vibration due to looseness may be detected by placing the finger tips on the first two components in the above list, in which case the defect is located very rapidly indeed.

Bumpers

These are supported from the front of the chassis by brackets held in position by four bolts and nuts, which may have worked loose. To ascertain if this is the cause, stand in front of the car, grip the car bumper with both hands and lift up and down to ascertain if the bumpers move independently of the car. It will be appreciated that even a small amount of play will cause a pronounced rattle.

Remedy.—Tighten bolts and fit new spring washers if found necessary.

Water is a lubricant to rubber and in wet weather will slide back and forth and give a mysterious knock. The bolts holding the absorber to the frame often appear tight but are not when the absorber is working.

Shock Absorbers

The shock absorbers in question are of course those located forward of the front wheels. Each end of the connecting rod (which links the pivot arm of the shock absorber with the axle) is enlarged to form an eye through which there is a rubber bushing. Weather and road conditions wear these rubber bushes and allow play on the connecting rod. The rattle can be reproduced by shaking the connecting rod quite lightly.

Remedy.—First remove nuts in order to free the connecting rod. Insert new rubbers and replace the connecting rod.

Springs and Shackle Bushes

These consist of about six leaves or strips and are secured as a unit to the chassis by shackle bolts at each end and to the front axle by two intermediate U-bolts. First ascertain if the shackles at each end are adequately greased. Also examine the bushes on the shackle bolts for wear and play. Next examine carefully each leaf of the spring to ascertain if they are all sound and well greased.

Remedy.—Unless one of the leaves of the springs has developed a

fracture the remedy is simply a matter of lubrication or replacing shackle bushes. The latter will necessitate jacking up the car from the chassis behind the spring, i.e. *not* from the axle. In the case of a broken leaf the car must be jacked up exactly as explained for the shackle bush. Next the shackle bolts must be removed from each end of the spring, then the U-bolts should be removed. It is usually better to "part exchange" the old spring for a new one in preference to inserting a new leaf.

Road-wheel Bearings

If, after eliminating all other possible causes of noise from the lower part of the car, the wheel bearings are suspected, it becomes necessary to jack up the car. This should be done from below the axle. Make sure that the brakes are free. If the wheel does not spin smoothly and quietly it will be necessary to get access to the bearings.

Incidentally, if there is the slightest cause for suspecting defective bearings they should be inspected without delay, as otherwise they may cause the wheel to seize and possibly lead to a serious accident.

The outer wheel cap and then the wheel must be removed. This reveals the brake drum and hub cap. On removing this cap the castle nut on the stub axle can be seen. Remove the pin, the nut, and the washer behind the nut, and then the brake drum can be drawn from the shaft. The bearings can then be seen. These consist of two collars, one inside the other, separated by small rollers. The rollers are kept apart at equal intervals by means of distance-pieces. It is of the utmost importance that the rollers should be kept so spaced apart, otherwise they will break or become jammed.

On no account should a new roller or ball bearing be inserted in a defective or maladjusted housing.

Remedy.—It is highly inadvisable to attempt to remedy a faulty bearing. This must be removed and renewed. The defect develops mainly through lack of lubrication.

DENNIS 35-, 40-, 50-, AND 60-CWT. GOODS-CARRYING VEHICLE

REAR AND FRONT AXLES AND BRAKES

REAR AXLE

General Description

THE rear axle is a very sturdy unit and is well up to the load imposed upon it under operating conditions. Power is transmitted by a spiral bevel pinion, through the spiral bevel crown-wheel, then, by way of the differential bevel gear, to the axle shaft, hubs, and road wheels. The driving shaft of the spiral pinion is carried on two taper roller bearings which take both journal and thrust loads. It is also supported by a roller spigot bearing at the extreme end which keeps the shaft perfectly rigid.

The crown-wheel and differential gear, also the hubs, are carried on taper roller bearings. The axle shaft and hub driving flange are made in one piece. It is a floating fit in the splined differential bevel-wheel. Adjustments are provided to ensure that the driving pinion and crown-wheel teeth are correctly engaged.

Lubrication

Special precautions are incorporated to control the lubricating oil. In the past, hubs have been treated as a separate unit, but in the Dennis design the hubs are included in the axle lubricating system. This is effected by omitting the usual oil-retaining joint at the inner end of the axle tube in order to allow the oil to circulate freely through to the tubes and up to the hubs. At the inner end of the hub is fitted a special type of oil seal which prevents leakage of oil on to the brake shoes. The design takes care to limit the oil retained in the hubs by tubes, through which all surplus oil drains back into the main axle casing. At the front end of the driving shaft is another special oil-retaining seal to prevent oil leakage at this point. Gear oil only should be used in the rear axle, which holds approximately $1\frac{1}{4}$ gallons. Both ends of the brake camshaft and the fixed end of each brake shoe are carried on oil-less bearings and therefore do not need attention.

Brake Shoes

One pair of brake shoes is fitted to each drum, the shoes being operated by both hand and foot. Fuller details regarding their operation will be given in the section of this article dealing with the brakes.

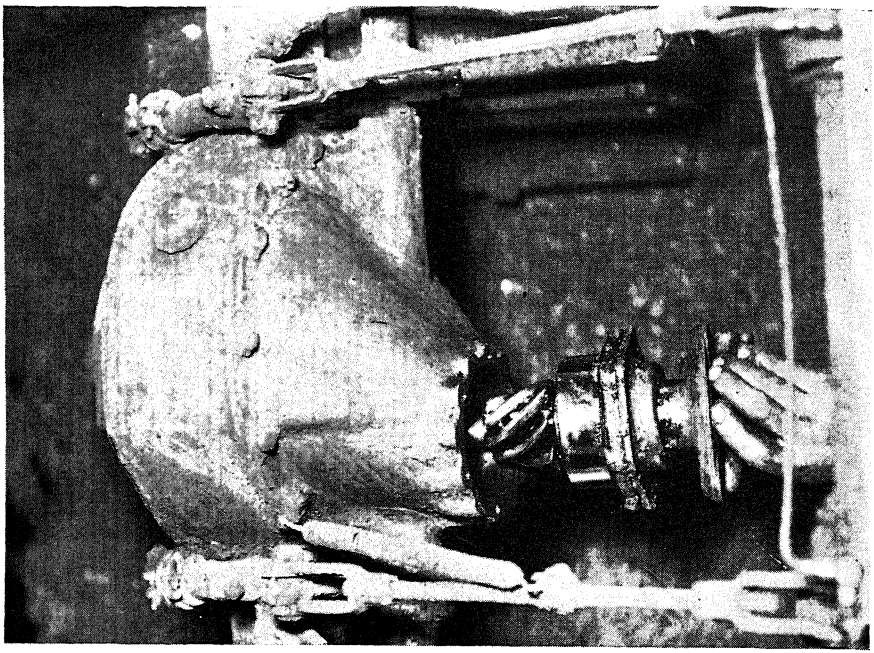


Fig. 1.—REMOVING SPIRAL PINION

Removing the Rear Axle

First disconnect the hand-brake rods where connected to the brake-operating levers, then the hydraulic expanders from the fixed bracket and operating lever (but not from the brake fluid pipe), and tie the expander up to the side of the chassis until the axle is refitted again. Next remove the bolts which connect the propeller shaft to the axle, remove the spring holding down bolts and the axle is free to be withdrawn from the chassis.

To Dismantle Rear Axle

With the axle removed complete from chassis, to commence dismantling first remove the driving hub flange nuts, then screw in the special withdrawal setscrews, which will draw out the axle shafts from the splined bevel-wheels of the differential. Having withdrawn the shafts, to disconnect the hubs lift up the tab of the locking washer, remove the locknut, when the tab washer can be taken off and the second locknut removed. The hub, together with the outer roller bearing, can then be pulled off, followed by the distance tube and the inner roller bearing, etc. Care should be taken in handling the special oil seal, because if this is

damaged in any way, leakage of oil will occur when reassembled. Furthermore, care should be taken that each oil seal is kept and refitted to its own hub if still usable, as if it is changed over it may not be effective in preventing oil leakage. If any doubt is felt at all in regard to these oil seals, it is best to replace them with new ones.

Removing Brake Shoes

The brake shoes can be dismantled by removing the fixing wire and the setscrews which secure them in position. The shoes can then be pulled off the oil-less bush which is fitted to the anchored end, while the expanding end will slide off the operating cam. The shoes are provided with inserts which can be replaced to take up any wear that may occur.

Removing the Brake Shaft

To dismantle the brake-operating shaft it is first necessary to remove the bolt on the shaft clamping clip. This will allow the cam and its short extension that fits into the splined end of the tubular portion of the shaft to be drawn out. The clip should now be driven back along the shaft towards the differential gear sufficiently to allow the shaft to pass through the cam housing far enough to let the end of the shaft come out of the oil-less bush. Now the end of the shaft should be pulled sideways away from the casing, and this will provide enough room to draw the shaft out of the camshaft housing in the spring and brake bracket.

Further Dismantling the Axle

Now it will be necessary to remove the whole of the interior differential unit, which is carried out by first removing the differential front cover, when the whole can be withdrawn without difficulty. The spiral pinion can be taken out by removing the setscrews which retain the cover plate and bearing housing in position. The primary shaft, together with its roller bearings and housings, can be withdrawn. To dismantle this unit, first remove the nut which holds the driving spider and draw this part off. The roller bearing fitted next to, and abutting on, the flange portion of the flange, can now be withdrawn by pulling off the pinion-bearing housing with bearing intact. This will leave one bearing in position, and it is important to take note at this stage of the shims for distancing out the bearing. Care must be taken that these are not lost.

Dismantling the Differential

First remove the wire, the adjusting locking ring pawl, and the nuts retaining the roller bearing cap in position. Having done this, take careful note of the exact position of the adjustment ring and *mark its position* on the fixed half of the housing. This will save time when reassembling and adjusting. Now lift the differential unit out, remove the bolts that clamp the differential cages and gear wheels, and the whole is then dismantled for attention.

Reassembling Differential

When reassembling the differential, first make sure that the differential pinion pins are clean and thoroughly lubricated and that there is no foreign matter between the faces of the cages. Make quite sure that the gear turns freely.

When mounting the crown-wheel on the cages, take particular care that no dirt is between the face of the cages and the crown-wheel face. If there is, it will probably cause the wheel to run out of truth and consequently be noisy, apart from the fact that under these conditions the wheel will work loose. Also see that all split-pins have been inserted and opened out. It will be noted that the differential cage bolts cannot turn owing to the flats fitting against the shoulder formed on the crown-wheel.

Assembling Driving Shaft

In the event of both differential and spiral shaft units having been removed, the first thing to do is to assemble the spiral pinion unit. First fit the roller bearing, with its back to the gear teeth, and then the bearing shims distance washers in position. Next fit the bearing housing over the first bearing and then insert the second bearing with its back to the spider. After making sure the face of the housing is clean, fit the washer for the cover plate.

The oil seal should next be fitted ; if there is any doubt about the one removed, it should be replaced by a new part. This should be soaked in oil before fitting. After having fitted the oil seal in position in the cover, fit this part on to the sleeve of the flanged driver. Then place the driver or spider with washer on the shaft and press home. Fit washer and nut and tighten up solid. Now hold the unit in a vice by the flange, keep the cover and oil seal close up to the spider and test the bearings for running play and adjust as necessary by the shims fitted between the two bearings.

It is important for the bearings to run with absolute freedom, otherwise crushing will result. On the other hand, there should not be excessive freedom as this will cause damage to the oil seal and also make the pinion and crown-wheel operate noisily.

Adjustments of Bearings (Later Models)

With the later models, the shaft of the differential spiral pinion is larger, and consequently the bearings are spaced more widely apart, than with the earlier type. The adjustment of bearings in this case is carried out with the oil seal pushed back against the flange of the driving flange to ensure absolute freedom when rotating the housing on the shaft driving adjustment.

To test the adjustment, with all parts in position, tighten up the nut which secures the driving spider as tightly as possible, hold the shaft in a vice in a vertical position and rotate the housing on the bearings. It

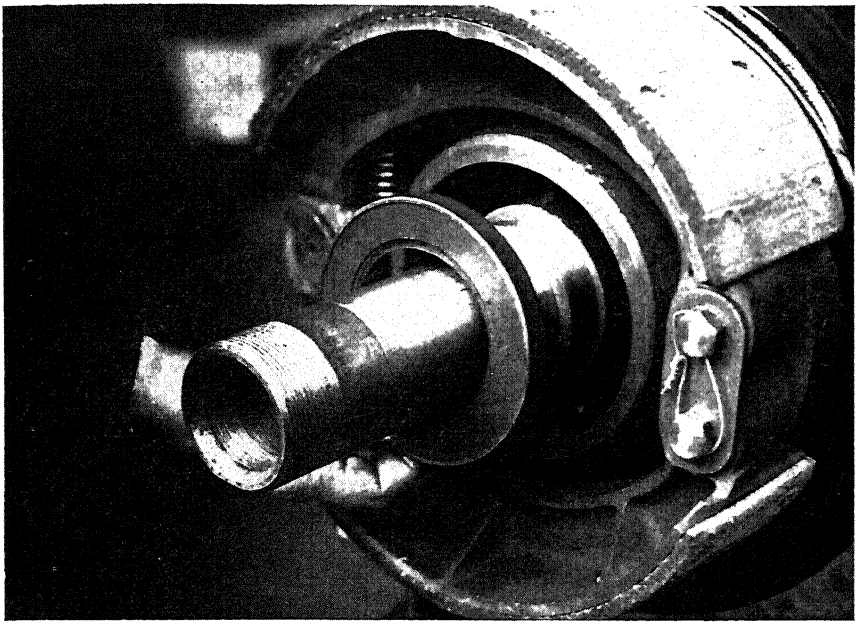


Fig. 2.—REASSEMBLING REAR AXLE HUB (1)

Placing the special oil-retaining seal in position. "Note" the lip of the leather points towards the bearing.

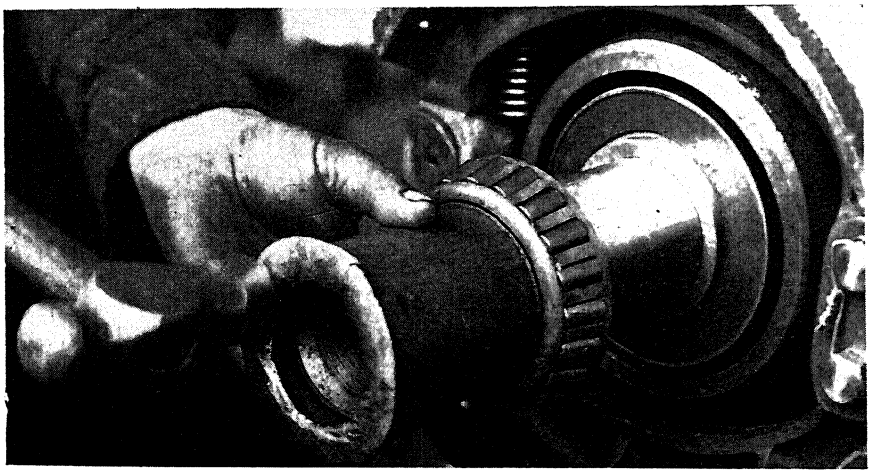


Fig. 3.—REASSEMBLING REAR AXLE HUB (2)

The inner roller bearing is then placed in position.

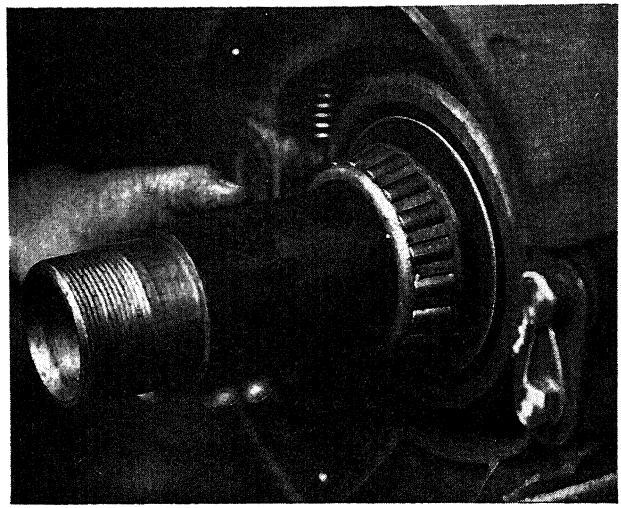


Fig. 4.—REASSEMBLING REAR AXLE HUB (3)
The distance sleeve is then placed in position.

ment depth can be adjusted by the insertion or removal of shims at the face joint of the pinion housing.

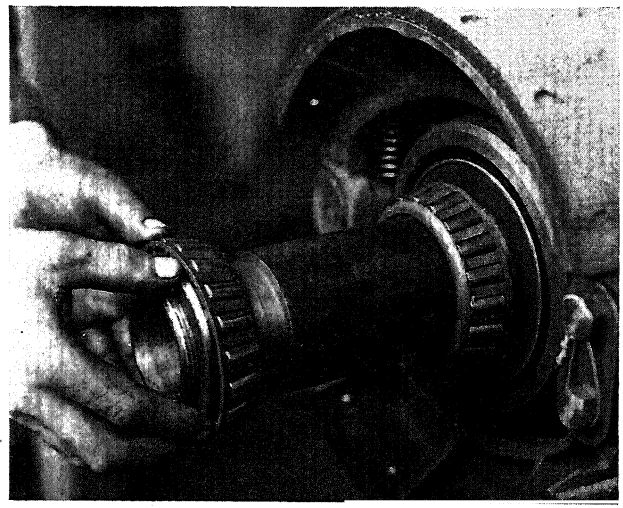


Fig. 5.—REASSEMBLING REAR AXLE HUB (4)
Showing how the outer bearing is fitted after the hub has been fitted.

should spin with absolute freedom and at the same time there should not be any end movement. If there is end movement or side play, remove the bearing shims and replace with some slightly thinner, or if the shaft will not rotate freely, then insert shims that are slightly thicker to obtain the desired results.

It should be noted that the correct tooth engage-

Fitting up the Unit

The differential pinion and crown-wheel can now be fitted in position. With the unit complete and bearings in position, their backs being towards the differential, place the unit in position to the marks previously made and fit the bearing caps, making sure that they are down in correct position on the adjusting threads. Now fit the setscrews and tighten up.

The parts should

be rotated for free running, also, the pinion and crown-wheel should be checked to ensure they are in full contact and that the ends do not overlap. There should be just perceptible play between the teeth, approximately ·004 in. After ensuring that all adjustments are completed and correct, finally make sure that all split-pins, tab washers, the wire fixing the adjusting ring, locking pawl, and the setscrews of the bearing cap are all properly secured.

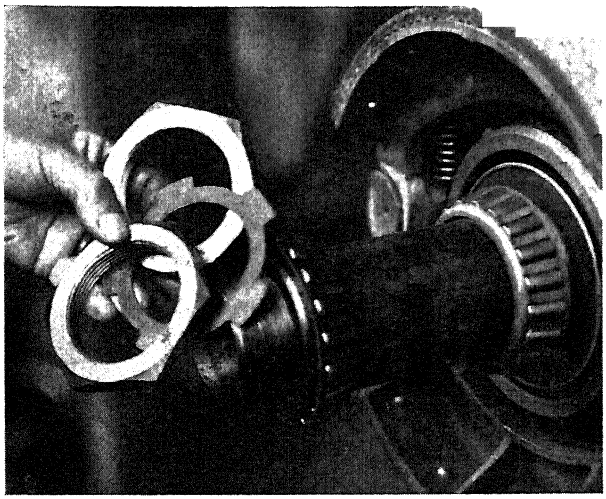


Fig. 6.—REASSEMBLING REAR AXLE HUB (5)

Showing the two locking nuts and tab washer that fits between them.

Fitting Parts in Main Cases

The unit can now be fitted to the main casing, but first of all see that the paper joint is in position and that some gear oil has been poured into the differential cages. Fit the paper joint to the rear of the case and the back cover and bolt up.

Next assemble the brake shaft with brake lever in position. Insert the splined end into the floating bush housing and then the other end in its bearing. Place the floating bush, spring, spring guide, and washer in position on the short camshaft, packed with a little graphited grease to protect the parts from damp. Then insert the shaft into the splined end of the tube, taking note that the clip bolt slot in the shaft corresponds with that in the tube, insert the bolt, and clip up tight. Now place the brake shoes in position, and when the pull-off springs are fitted the position of the brake lever should be verified. It should stand at an angle of approximately 15° behind the centre line of the shaft when held against the adjustment screw. Any alteration necessary can be made by moving the camshaft a spline either way to suit requirements.

Fitting the Hubs

The hubs can now be fitted. First place the roller bearing in the back of the hub with its back outwards, then fit the special oil seal, with the

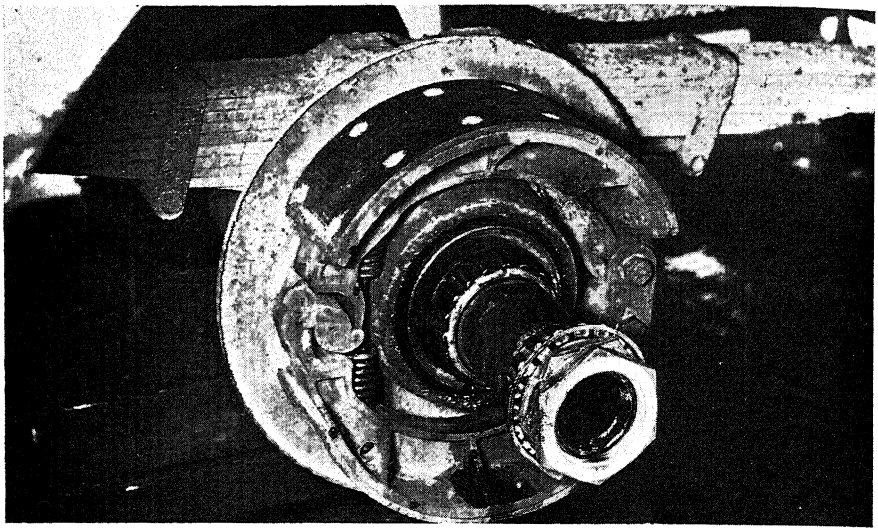


Fig. 7.—REAR AXLE HUB REASSEMBLED

edge of the pliable material towards the bearing, and insert the collar that fits inside the oil seal. Now push the hub on to the axle and fit the tubular distance piece, followed by the second bearing, facing towards the one already fitted.

Add the first locknut; tighten this up and test hub for spinning freely before fitting the tab washer and second locknut. There should be just perceptible play. Carefully double-check the adjustment and finally hammer over the tab on to the flat of the outer nut.

Fitting the Axle Shaft, etc.

The axle shafts are the next parts to be assembled. Place the paper washer on the hub face and insert the axle shaft. Bolt up the driving flange to the hub, but make quite sure that the withdrawal screws are right back and not preventing the faces coming into close contact. Half a pint of gear oil should be pumped through the special lubricator provided in each hub and ten pints in the main rear axle casing. The oil-level should be re-checked when axle is assembled to chassis.

FRONT AXLE

General Description

The front-axle design on the Dennis lightweight goods range of vehicles is somewhat unorthodox. The front-axle bearer is constructed with deep jaws at the ends. The swivel axles are fitted inside these and are so designed that the centre line of swivel passes through the centre

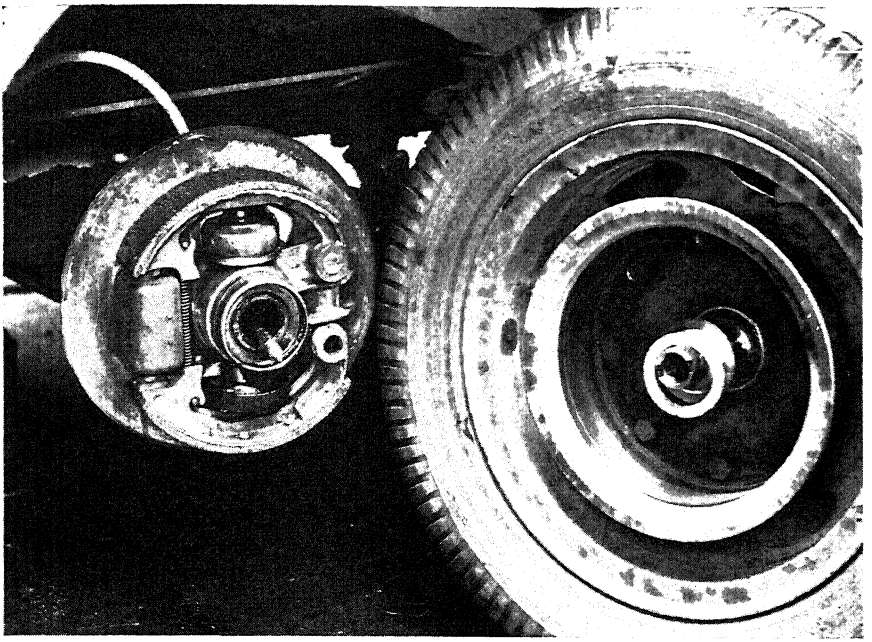


Fig. 8.—FRONT WHEEL HUB

of the tyre and gives centre point steering. The weight of the front axle is taken on a floating-bush bearing fitted into the top of the jaw. The working faces are set at an angle which makes this bearing self-adjusting. The bottom bearing is a bronze bush, closed at one end and held in position by a flange formed with the casting. It is of interest to note that there is a slight alteration of the usual order, inasmuch as the outer ring of the roller bearing is fitted in the swivel and the inner ring on the rotating axle, which is made in one piece with the nave plate, carrying the brake drum and wheel disc. The wheel studs and nuts are made with special self-locking threads. The combined nave plate and axle is held in place by a long stud fitted in the back plate, which passes through the axis of the axle and is secured by a nut retaining the axle in position.

In addition to the roller bearings mounted on the axle, there is a distance piece for adjusting the bearings, and on earlier chassis an oil circulator. The latter is in the form of rotating scoops which pick up oil from the wheel and throw it on to adjacent parts, thoroughly lubricating the bearings. Lubrication for the bottom bush is provided by way of the oil-controlled wick communicating with the oil well.

To prevent the leakage of oil from the swivels and bearings, special oil

seals are fitted and, furthermore, provision is made to prevent oil getting to the brake liners.

Brake Shoes

The brake shoe liners are $3\frac{1}{2}$ in. wide and $\frac{3}{8}$ in. thick. The shoes are operated by a hydraulic expanding cylinder situated between the ends of the shoes. The end of the shoe, which is anchored, is provided with oil-less bearings and fitted to pins located in the mounting.

Track Rod, etc.

The orthodox type of track-rod lever is eliminated from this type of chassis, the special mounting having been formed to take its place. The track-rod pin operates in a spherically shaped block, the ends of which are radiused to fit the spherical housing in the track-rod end and in which the block is a running fit. This block or centre-piece, as it is generally described, relieves the track-rod pin of any strain which may occur due to any change of angularity that takes place.

Removing Front-axle assembly from Chassis

To remove the front-axle unit complete from chassis, first take off the wheels, next disconnect the coupling bar to the steering-box at the axle end. Now undo the brake fluid pipe at the joint where it is bolted to the angle bracket fitted to the brake mounting and to prevent excessive loss of fluid fit a small plug in the end of the flexible pipe. Next tie the pipe to the chassis with its end pointing upwards and above the level of the pipe leading to the master cylinder. Finally, remove the front spring holding down U-bolts, and the front axle complete can be withdrawn.

Dismantling Axle and Swivels, etc.

Having removed the front axle complete from chassis, to dismantle the swivel axle first remove the dress-guard by taking off the nut and washer which secures same. Next remove the large nut to enable the axle nave plate and brake drums to be withdrawn. Now remove the brake shoe springs, pull open the brake shoes, and remove the hydraulic expander, the anchor pin setscrew, and the pin. The shoes can now be dismantled. Next detach the track-rod pin and steering lever, when the swivel is free for complete dismantling. Undo the setscrews which secure the flanged bush, and remove along with oil tray from the lower part of the axle jaw, when the swivel will drop sufficiently to allow the bearings to leave the housing. Now, by tilting the top of the swivel over, the whole can be lifted from the axle. Note should be taken of the packing shims located in the bottom of the bearing, which are provided to regulate the amount of end play allowed in the swivel. The remaining parts can now be dismantled without difficulty.

To Reassemble Swivel

First of all, make quite sure the swivel is quite clean and ready for assembly, then place the axle bearing at the steering lever end in position, with its back outwards. *Note* there is a difference in the shape of the ends, one being shaped to receive the oil-retaining cork washer and the other the bearing-retaining ring. Now insert the distance tube and oil circulator, making quite sure that the cup of the latter faces to the direction of rotation, and then fit the outer bearing.

Place the retaining ring, with paper washer to prevent oil leakage, in position, and the back plate fitted with the long stud. Next, position the oil-retaining cork washer with the pressed-steel backplate towards the roller bearing, fit the distance collar and oil collection cover in place and tighten the clip which secures it in position.

Fitting Swivel to Axle

The order of assembly is to first place in position the oil seal, bearing, and cover plate. Take care that the oil control wick is in position and then insert into the bottom bearing housing. Now place the distance ring in position through the hole, followed by the oil seal, and flanged bearing with its adjusting shims in position in the bottom. Lift all the parts into position and fix the oil drip tray, etc., with the setscrews, and wire these up.

The brake shoes should next be assembled in position, the anchor pins inserted, and setscrews tightened up and wired. Finally, fit the hydraulic expander cylinder and brake shoe pull-off springs.

Fitting Track Rod

The track rod should now be fitted to the steering yoke. First of all, insert the spherical centre-piece, then place the helical spring and dirt-excluding washer in position, followed by the bronze washer. Place the track-rod pin in position in the yoke and fit the track-rod pin. Make sure to split-pin the slotted nut.

Assembly of Swivel Axle and Brake Drum

After having already fitted the brake drum to the nave plate, and with the oil-retaining gasket in position, insert the swivel axle into the bearing assembly. If the distance tube has dropped, it can be lifted into correct alignment by using swivel axle retaining stud for the purpose. It is very important to make quite sure that the axle engages with the dogs cut on the backplate. After tightening up the nut which secures the swivel axle and nave plate, test the wheel for spin. *Note* this nut is not an adjustment for the wheel bearings and must be kept fully tightened and checked regularly. Now adjust the special eccentric adjustments until both brake shoes rub slightly. Turn it back until the drums revolve without rubbing, and then securely lock the eccentrics. With a paper

washer in position, the combined cover cap and steering lever can now be fitted. Check over carefully and pump in half a pint of gear and engine oil.

Front Wheel Track

Measured at equal heights from the ground, the distance between the runs at the front and back of the front wheels should be equal. A toe-in of not more than $\frac{1}{16}$ in. is permissible. The track rod has right- and left-hand threads for executing this adjustment correctly. The wheel-locks should be adjusted when the axle is fitted to the chassis, by regulating the screw which retains the cover plate in position. Packing washers under the head of the screw should be used for this purpose.

BRAKING SYSTEM

Braking is by the Lockheed hydraulic system. The Lockheed system of braking is dealt with in Vol. I. The following notes, therefore, are confined to the mechanical side of the Dennis brakes only.

Removing Master Cylinder from Chassis

First drain the fluid supply tank. To do this conveniently, disconnect the pipe at the cylinder head, depress the brake pedal slowly, allowing the fluid expelled to flow into a clean container. Repeat this performance until the tank is drained. Detach the push rod from the foot pedal, undo the three bolts which hold the cylinder to the chassis and remove the cylinders.

To Dismantle Master Cylinder

Remove the rubber foot and spring clip and stop which retain the piston, then draw the piston from the barrel. The piston cap, return spring, and check valve are then removable. Any necessary cleaning must be carried out with Lockheed brake fluid. Petrol or paraffin should never be used.

Reassembling Master Cylinder

Dip all the parts in Lockheed brake fluid. Hold the cylinder vertically during assembly. Insert the valve assembly in the large end of the spring and drop it into the cylinder. Insert the master cylinder cup and press it firmly on to the end of the spring. Replace the piston and secondary cup and complete assembly.

Front Brake Expander (Internal)

The front brake expander is mounted rigidly to the brake shoe mounting and the opposed piston acts through push rods directly on the tips of the brake shoes. The ends of the cylinder are fitted with rubber boots.

At the uppermost position and between the opposed piston is a bleeder screw. This is required for expelling all air when filling the system. To remove the front brake expander first disconnect the copper tubing from the hose connection at the axle end, then remove the nut and lock washer, when the hose union may be removed from the bracket. Fit a small wooden plug into the end of the tube to prevent the fluid escaping and tie it up with the end pointing upwards. Take off the brake drum and unhook the brake shoe return spring. Remove the two setscrews holding the cylinder to the back plate, and the cylinder can be withdrawn.

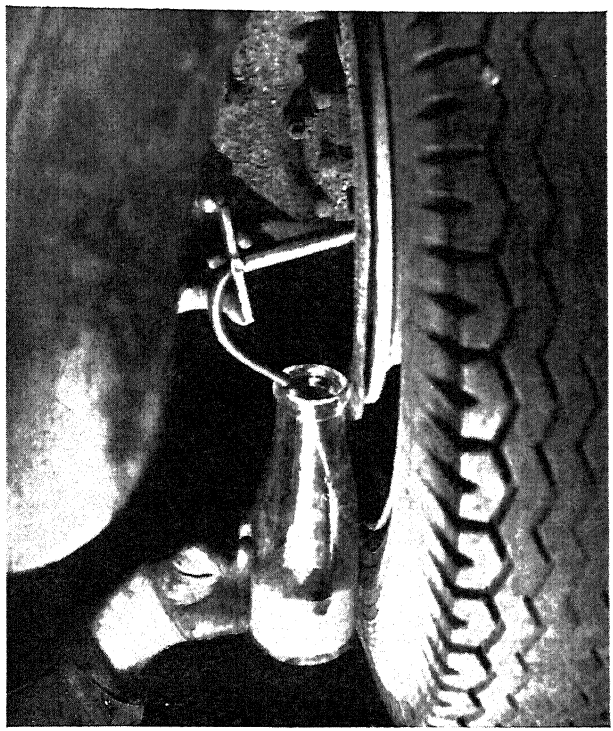


Fig. 9.—BLEEDING THE HYDRAULIC BRAKE SYSTEM

Rear Brake Expander (external)

The rear brake expanders are mounted at one end to a fixed portion of the axle and at the other end to a lever operating through a second lever, the brake camshaft. The cylinder proper is made up of a steel stamped head into which is screwed a tubular steel barrel. The joint between these two parts is made by a copper gasket. *The head and barrel must not be dismantled for any purpose whatsoever.*

Sliding in the cylinder barrel is a hollow fork-ended piston carrying a rubber cup, which acts as a pressure seal. The outward travel of the piston is governed by a screwed cap fitted on the end of the cylinder barrel. Dirt and water are excluded by a rubber boot, one end of which is clipped to the cylinder barrel whilst the other is clipped to the piston fork end. Fluid enters the cylinder head via the flexible hose attached by means of a

connection, and a bleeder screw is provided for expelling air from the pipe-line.

Removal of Rear Brake Expander

Remove the screwed plug holding the fluid pipe fitting to the cylinder head and insert a plug and tie it up with the end pointing upwards to prevent loss of fluid. Then disconnect the expander at its forked ends.

The flexible hose connections to the expanders should be examined frequently for any sign of leakage and any leaky hose replaced immediately.

Bleeding the Line

Whenever any part of the system has been disconnected it becomes necessary to " bleed " the system in order to expel all air. The supply tank should be filled with Lockheed fluid before commencing this operation and the tank kept at least half full of fluid during the whole period of bleeding. First slack back the front brake adjustment cams as far as possible, as unless this is done there is a possibility of trapping a pocket of air in the cylinder. Remove the setscrew from the end of the bleeder screw and screw in the bleeder drain, which is a special screwed brass nipple fitted with a rubber tube. Slide a box spanner over



Fig. 10.—ADJUSTING REAR BRAKE SHOES

Jack up rear axle, slacken off locknut and screw up the setscrew shown until the brake shoes just touch the drum. Slacken off to just free the drum and retighten the locknut.

the tube and allow the rubber tube to hang into a clean glass container. Unscrew the bleeder screw one turn of the spanner and depress the foot pedal quickly, allowing it to return fully without assistance. This gives a pumping action which forces fluid out at the wheel expander, carrying with it any air that may be present. Not less than ten strokes of the foot pedal will be necessary to bleed each wheel expander. Watch the flow of fluid from the bleeder drain, the end of which should be kept below the surface of the fluid, and when all air bubbles cease to appear, close the bleeder screw.

The bleeding operation must be repeated on each brake expander and the supply tank replenished each time. Should the supply tank be drained during the bleeding operation, air will be drawn into the system of this point, necessitating rebleeding.

Brake Adjustments

When the brake shoe linings have become worn to a stage where the foot pedal goes almost to the floor board, it will become necessary to adjust the brake shoes with closer relation to the drums.

Front Brake Shoes

On the mounting that also forms a cover plate for the front brake shoes will be found two screws with square heads which are fixed in position by locknuts. The inner ends of these screws are formed in the shape of a cam and press against the webs of the brake shoes. By rotating the screws by the square end the shoe can be moved towards or away from the drum.

Therefore to adjust, jack up the front axle, turn the screw until the brake shoes rub on the drums, then slacken off to allow the drum to rotate freely. Tighten up the locknut securely. Test each shoe in exactly the same way and when finished all front brake shoes will be properly adjusted.

Rear Brake Shoes

At the inner end of the rear brake shaft is a setscrew fixed in position by a locknut. It will be noted that the setscrew point presses against the lever connected to the hand brake pull-rod. This latter lever is also pushed by the head of the link which is connected to the brake expander. Therefore to adjust the rear brake, jack up the rear axle, slacken off the locknut and screw up the setscrew until the brake shoes just touch the drums. Then slacken off to enable the drum to rotate freely without rubbing. Make quite sure to tighten the locknut.

Proper Adjustment of Brake Pedal

It is important that the brake push-rod should have a slight clearance where it seats in the master cylinder pistons when in the off position. Should the push-rod be adjusted tightly against the piston, the port hole

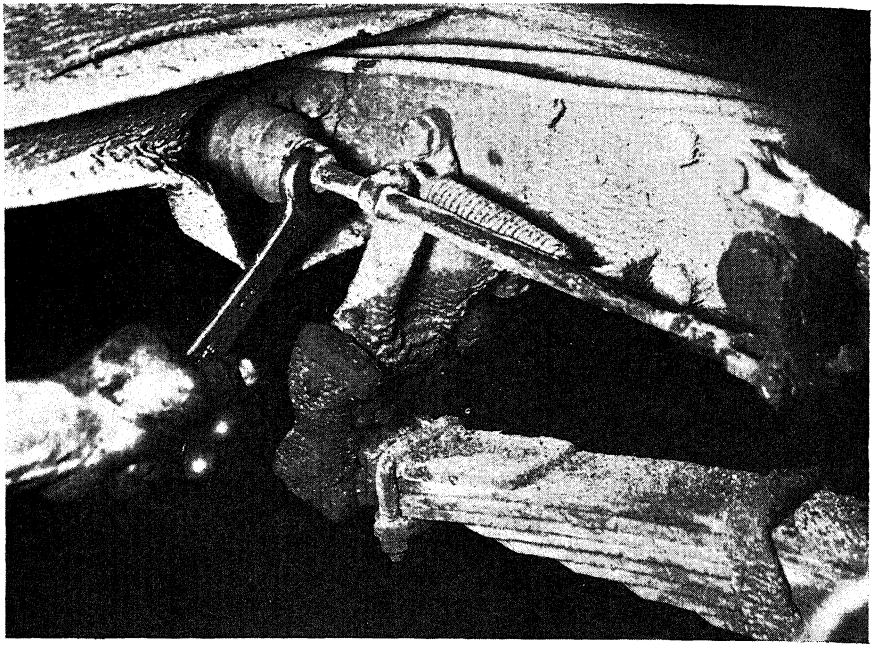


Fig. 11.—ADJUSTING LOCKHEED MASTER CYLINDER PUSH-ROD

in the cylinders will be covered by the cup washer, thus preventing the compensating action of the Master cylinder and causing dragging brakes.

Hand Brake Lever

The position of the hand brake levers can be adjusted at the fork connection on the short pull-rods. Make sure that the locknut is tightened securely, but any alteration of position due to wear of the brake linings must be corrected by an adjustment of the special screw provided at the rear brake drums.

HILLMAN MINX

REAR AXLE, FRONT AXLE, AND CHASSIS REPAIRS

REAR AXLE

THE rear axle of the 1939 Minx is of the semi-floating type incorporating a spiral bevel drive. In design it is essentially straightforward, but as the position of the crown wheel relative to the pinion requires accurate adjustment, as far as possible the original adjustment should not be deranged.

Provision is made for the adjustment of all roller bearings in the differential and bevel-pinion assembly. The complete differential unit with crown wheel and bevel pinion is detachable as a unit from the axle assembly. This should be done when it is necessary to carry out work on the differential unit.

Oil Seals

A spring-loaded leather oil seal, built up in a steel cage, is fitted just to the rear of the propeller-shaft coupling.

After a considerable mileage, it may be necessary to replace these oil seals, and it should be noted that the latest-type oil seals, made of greenish-brown leather, should be soaked in engine oil at 80° to 90° F. for two hours before fitting, if not already treated.

The cage in which these oil retainers are built is a steel pressing, and it cannot therefore be guaranteed that this will make a perfectly oil-tight fit in the recess machined for it.

Whenever replacement oil seals are fitted, therefore, the outside of the cage should be coated with a liquid jointing compound before the seal is pressed into position. These seals operate most effectively in one direction, and thus they should be fitted with the sharp edge of the leather facing the rear axle.

Hub Oil Retainers

Should leaks occur at the rear hub, before rectification is attempted steps should be taken to ascertain if the rear-hub bearings of the back axle have been over-lubricated. The retainers fitted and described later are usually adequate, but no retainer can hold back excessive quantities of lubricant.

On all hubs, front and rear, a catcher is spun on to the rear of the hub

so that the results of overgreasing are caught in these catchers, and a leakage will occur into the hub of the wheel behind the nave plate. It is obviously important that these drain holes from the catchers drilled in the hub, brake drum, and wheel should be kept clear, as otherwise the catcher may become overfilled and the grease will eventually reach the brake linings.

In the case of the rear hubs a further cup-type catcher is spot-welded to the bearing retainer plate. The edge of this cup protrudes within the catcher on the hub so that under all circumstances the grease is led away to the wheel hub without reaching the brake-shoe linings.

Two oil seals are fitted in each hub, as follows. In the axle casing an oil seal, of a similar design to that already described for the pinion housing, prevents oil from the differential passing along the shaft. The second oil seal is a felt washer built up in a pressed-steel cage, which in turn is fitted in the catcher spot-welded to the bearing retainer plate. In all cases the pressed-steel cages of these oil seals should be coated with a liquid jointing compound before fitting.

To Remove and Replace Axle Shafts

Remove the following in the order given : Road wheel, water excluder from brake backing plate, setscrews securing brake drum, brake drum, red and black springs from brake shoes, spring passing across brake adjuster.

Push the shoes outwards, and remove the three nuts securing the hub-bearing retainer plate, now push brake shoes back into the normal position.

Refit the water excluder, and replace brake drum and road-wheel nuts and tighten evenly. This will withdraw the shaft nearly out. A slight leverage placed behind the brake drum when the wheel nuts are fully tightened will completely release bearing from casing.

In replacing, the operation is straightforward, except that care must be taken to place the retainer plate so that the clearance in the plate for two nuts in the backing plate is opposite these two nuts.

To Dismantle and Rebuild Axle Shafts

When it is necessary to examine the oil seals, as described in the preceding paragraphs, the shaft having been removed must be dismantled as follows :

Knock down tab of lock washer, remove nut. Draw off rear-hub bearing by means of special hub-bearing drawer. The retaining plate complete with oil seal may then be taken off the shaft.

The oil seal is pressed into the cup welded on the retainer plate. It is important that the cage of this felt oil seal should fit tightly into the cup welded into the retainer plate, and jointing compound should be used on the outside of the cup.

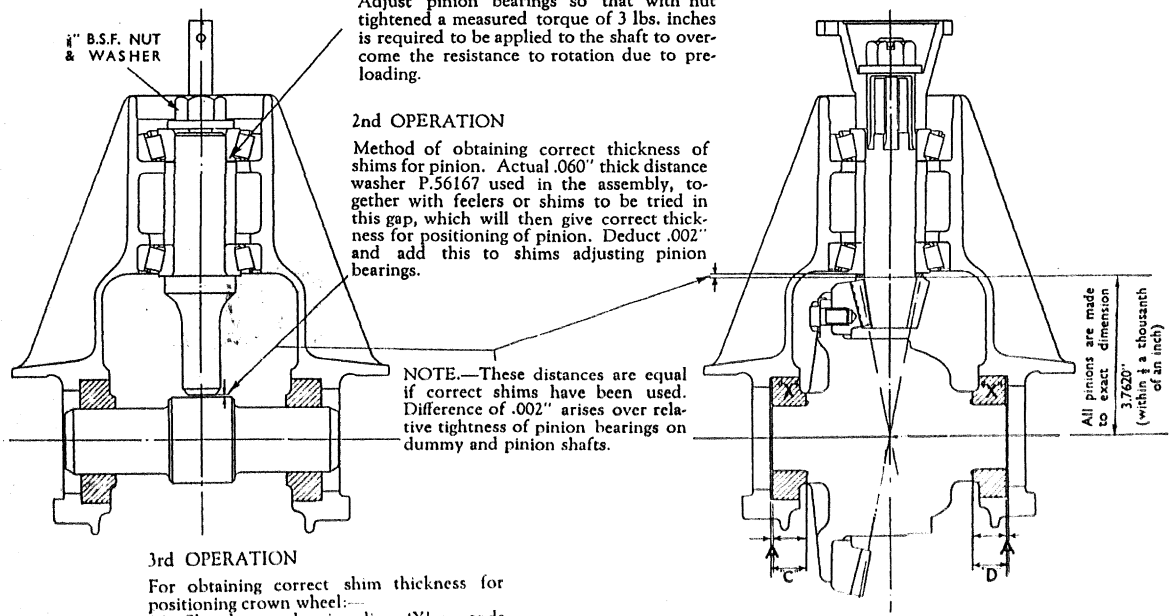


Fig. 1.—Jigs used in adjusting crown wheel and bevel pinion, Hillman Minx

Rear-axle Breather

If at any time the rear cover of the axle is removed, it should be noted that whereas the cover is secured in most cases by setscrews, in one case a stud is used. This stud should be fitted in the hole approximately at one o'clock when the axle is viewed from the rear. An examination of the stud will reveal that it is drilled to provide a breather for the rear axle and if replaced in any other position might easily cause trouble through oil leakage.

Differential Unit

The design of this unit has been altered on the 1939 Minx with a view to providing a very much more rigid construction, coupled with special lubrication scheme which ensures that all parts are continually receiving large supplies of lubricant. On the other hand, when adjustment is necessary it can easily be carried out by the use of simple special tools obtainable through Messrs. V. L. Churchill and Co. Ltd. These tools can be used sucessfully owing to the fact that the locality faces on the crown wheel and pinion are tied to an accuracy within ·0005 in., and thus with the use of these tools the adjustment of this unit is very much quicker and surer than on any previous model.

To Dismantle Differential Assembly

When removing the differential box complete with bearings, take care that the outer rings of these bearings are not interchanged one side with another. Remove split-pin and nut securing coupling to pinion. Remove coupling. Drive bevel pinion out. It will become detached with the distance-piece and shims. This distance-piece with shims controls the adjustment of the bearings supporting the pinion.

To Dismantle Differential Box

Knock out taper pin securing trunnion shaft in differential box. Push out trunnion shaft. The trunnion wheels complete with thrust pads can then be carried round and brought out through the openings in the differential box. The axle end wheels can now be taken out of the differential box through the same openings.

The rebuilding is a direct reversal of the above.

To Assemble and Adjust Complete Unit

Withdraw rear Timken bearing from pinion shaft. Place rear bearing on dummy shaft. Place shims and distance-piece on dummy shaft. Remove oil seal from nose of casing. Fit dummy shaft into casing and outer bearing on dummy shaft. Fit coupling nut and washer and tighten fully.

Check these pinion bearings for adjustment, which can be altered by

removing or fitting shims at the end of the distance-piece between the two bearings.

When correctly adjusted the bearings should be pre-loaded, i.e. tightened beyond the normal position for free movement. The extent of the pre-load is measured by testing the torque required to turn the shaft, which should be 3 lb. in., i.e. a pull of $\frac{1}{2}$ lb. on a lever arm of 6 in. The lever arm can be fitted into the tommy-bar hole in the dummy shaft, and a spring balance used to apply the load.

Having established this pre-load, fit the centre jig into the casing, using the two dummy bearings as shown in Fig. 1. A gap will exist between the end of the dummy shaft and the centre of the centre jig. The gap should be measured with feeler gauges and the original spacer washer, as shown.

The measurement taken with feeler gauges is the thickness of the shims required to be built on to the pinion shaft when reassembled. In practice, however, it is found that as the bearing is placed on to the pinion shaft it alters in length to the extent of ·002 in. This should therefore be subtracted from the thickness of the shims which would be required to fill the gap and added to the shims at the end of the distance-piece between the bearings.

Place the thick washer, *chamfer downwards*, then the correct thickness of shims on the pinion shaft. Press on the inner member of the rear bearing. Place the shims with ·002 in. added, then the distance-piece, on the pinion shaft. Refit oil seal to casing. Rebuild pinion into casing.

When fitting the oil seal the outer cage should be coated with a quick-drying jointing compound.

This completes the assembly and adjustment of the pinion.

Having reassembled the differential box, extract the two bearings and in their place fit the dummy bearings without shims.

Place the differential box carried on the dummies in the casing and fit the caps.

With a suitable length of tubing drive the dummies inwards until the correct backlash exists between the gears. (*See* Fig. 1.) Measure with feeler gauges the gaps at the points *A*.

Obtain the distances *C* and *D* by adding together the thickness of the feelers plus ·8 in., the thickness of the dummies.

Measure exact overall height of actual bearings to be used (*see* notes below) and subtract from dimensions *C* and *D*.

This will give the actual shims required, but it is advisable to add ·001 in. to each side owing to the impossibility of working to the full measurement with feeler gauges.

Make a very careful note of the above measurements.

Remove differential box from casing, place shims in position, press on bearings, replace differential box in casing, and refit caps.

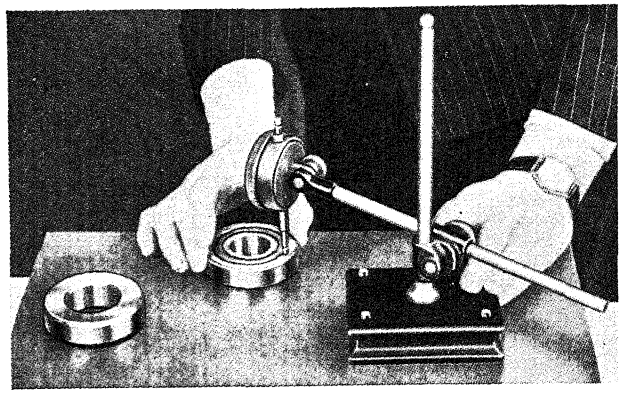


Fig. 2.—METHOD OF MEASURING HEIGHT OF DIFFERENTIAL BEARING

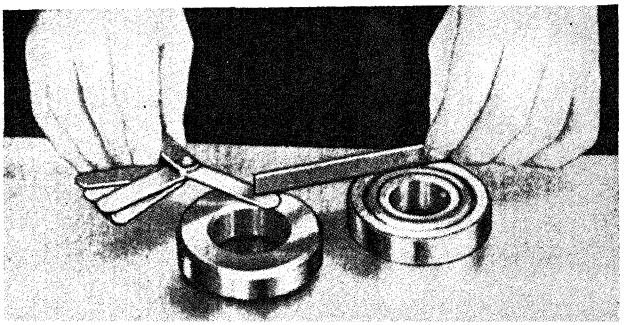


Fig. 3.—ALTERNATIVE METHOD OF MEASURING HEIGHT DIFFERENTIAL BEARING

These caps are of such a size that they give the correct pre-load to the bearings automatically.

To Measure Overall Height of Timken Bearing

This may present a little difficulty, but may be carried out by one of the two methods described below.

The first method is to use a dial gauge suitably mounted on a surface-plate and set to zero by the use of the dummy bearing. The reading then taken on the actual bearing, as shown, gives the difference.

In the absence of a dial gauge the relative heights of the bearing and the dummy can be compared with the use of feeler gauges if they are both placed on a surface-plate.

Irreparable damage will be done to the bearings if they are not extracted with the proper tools.

As pointed out in the first place, this system of assembly ensures the correct adjustment of the differential unit. If it is considered desirable to check this adjustment, it may be done by lightly coating the crown-wheel teeth with red lead or Prussian blue. It should then be revolved in both directions against the pinion, when the marking shown in Fig. 4 should be obtained.

In the majority of cases it is quite unnecessary to remove the rear axle from the chassis frame.

FRONT AXLE

In the event of a front-axle beam becoming damaged in an accident, it is strongly recommended that a reconditioned unit, which has been set

and correctly heat-treated, should be obtained from the Factory Service Department.

A taper packing is fitted between the axle and the springs. When replacing this, the thick end of the packing should be to the front.

When refitting a front axle, the U-bolts should be finally tightened when the weight of the car is on the springs.

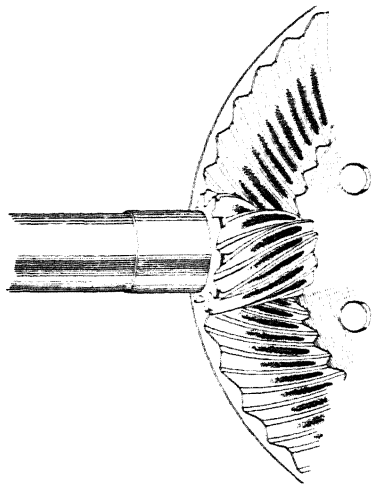


Fig. 4.—MARKING OF CROWN WHEEL AND BEVEL PINION WHEN CORRECTLY ADJUSTED

Front Hubs

It should be noted that a grease catcher is spun on the inside of the front hubs so that, should the hubs be greased excessively, the leakage which must inevitably result is caught by this catcher, the catcher being emptied through holes drilled in the hub, brake drum, and road wheel. These holes must be kept clear.

To Adjust Front Hubs

It is most important that an appreciable shake should be noticed and under no circumstances must the whole of this be absorbed. The actual measurement of the end float should be from ·010 in. to ·020 in. If necessary, remove split-pin and adjust castellated nut. Relock with new split-pin.

It should be clearly understood from the above that there can be no question of taking up front-hub bearings to eliminate any form of steering kick or wobble.

The wheel is removed so that the degree of shake can be tested accurately.

Thrust-bearing Construction

It will be noted that between the axle beam and the top of the lower swivel-pin bush a thrust-pad is fitted, made of special composition. These thrust pads should be a tight fit between the beam and the stub axle, i.e. vertically.

Wheel Alignment

Normal track adjustment is so that the front wheels toe-in to the extent of $\frac{1}{8}$-in.

The toe-in must be checked only when the wheels are pointing straight ahead. Adjust track by slackening back nuts at both ball joints and turning track rod. Relock the rod when correct adjustment has been obtained.

Steering Angles and Dimensions

As the following steering angles and dimensions are taken in some cases relative to the ground, the angles will be correct only when the car is level and is loaded to its normal static position. The latter can be ascertained by checking the spring cambers. To test the spring cambers on both front and rear springs, stretch a piece of strong thread across the centre of the spring eyes. The distance from this cord to the top of the top or master leaf is the spring camber. In the case of the front springs it should be 1 in. above, and in the case of the rear springs $1\frac{9}{16}$ in. below.

Having loaded the car to this, the castor angle can be checked. This angle is the slope of the swivel pin in a fore-and-aft direction, and is arranged so that the swivel pin is inclined backwards from the bottom. As there is no twist in the axle beam itself, the castor angle can be checked from the spring pads, and for this purpose we suggest the use of a rule exactly 3 ft. long. This is placed on the spring pads, and owing to the castor angle will lie at an incline. The distance from the ends of this rule to the ground can then be measured. If x is the distance from the rear end of the rule to the ground, the front-end height should be x plus 56 mm. Packing-pieces are incorporated between the spring and the axle to set the axle in accordance with this recommendation. The thick end of the packing should be fitted to the front.

Wheel Chamber

This is the angle of the centre-line through the wheel to the vertical. In the case of the Minx this should be $1\frac{1}{2}°$. It is felt that this can be satisfactorily tested only by the use of one of the special gauges which are marketed.

Swivel Pin

The swivel pin is at an angle sideways. This is to reduce the load on the swivel pin bearings and obtain what is known as " centre-point steering." The angle in the case of the Minx is $7\frac{1}{2}°$. Here again, one of the special gauges marketed is recommended.

Position of Ball Pin

This is a matter of extreme importance, the ball pin referred to being the one to which the push-pull rod is connected. It will be appreciated that this ball pin is so positioned that, when the axle moves, the ball pin is carried through an arc, the radius of which is the length of the push-pull rod attached to it. If the position of this ball pin is in the least upset, steering reaction, i.e. the transmission of the road bumps to the steering box and wheel, is felt. The position of the ball pin is on the centre-line of the axle beam when the wheel is straight ahead. The height of the face into which the ball pin is screwed above the face of the spring pad is 76 mm.

Steering Joints

In all four cases, the ball joints used on the track rod and at the ends of the side steering tube are entirely self-adjusting. These are of special construction and are supplied only as an assembled unit. The design is such that, provided they receive regular attention using a soft grease or gear oil, long periods of satisfactory service will be given.

If plays exists in the ball joints, this may be due to the fact that the self-adjusting mechanism has become jammed or rusted up and is not, therefore, operating. Before the ball joint is replaced, therefore, grease should be applied and the joint worked to see if the self-adjusting mechanism can be released and made to operate.

Should play exist and it is found impossible to remove it by greasing, the replacement of the complete joint will be the only cure.

CHASSIS

Bonnet and Radiator

Adjustment is provided so that the radiator shell can be positioned to fit the bonnet. This adjustment is very simply carried out. Provision of this nature overcomes the difficulties which used to be experienced when it was necessary to change a radiator or fit a replacement shell.

Slacken the three nuts securing the radiator shell to the block on each side, also the countersunk screws which pass through the lug for the bonnet hinge. Slacken the two screws securing wing to lower portion of radiator shell, one each side, and the two nuts and bolts securing wing to lower portion of radiator shell, one each side.

The shell can then be removed into any position which is desired, and thus the bonnet will fit satisfactorily.

Should it be found necessary to draw the radiator bodily towards or away from the body, i.e. to accommodate a long or short bonnet, this can be done by adjusting the two tie-rods which couple the top of the radiator to the dashpan.

Shackles

Except in the case of the front spring front shackle, the shackle bearings are composed of "Silentbloc" bushes. In the case of the front spring front shackle, the build-up is as follows: Pressed into the front-spring eye is a bronze bush. Over the shackle pin a hardened steel distance-piece is fitted, which controls the distance between the two thrust-washers which are located on the pin. When assembled, the thrust washers are nipped on to the steel distance-piece or bush so that (*a*) this steel bush does not turn on the shackle pin, (*b*) the end float on the shackle is established at ·003 in.

The "Silentbloc" bushes of patented construction consist of an inner and outer steel tube, between which rubber of special composition

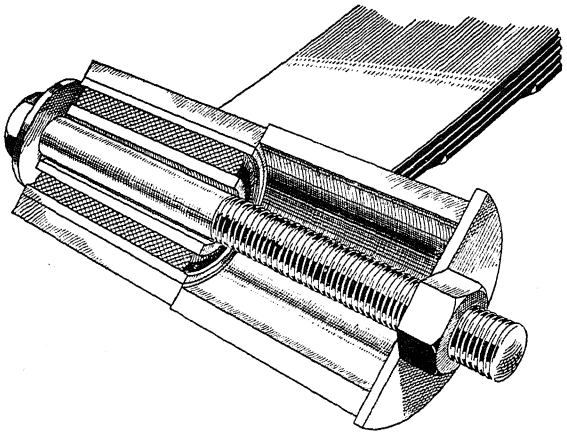


Fig. 5.—METHOD FOR REMOVAL OF BUSHES FROM SPRINGS OR CHASSIS FRAME

is arranged. In action the inner and outer tubes are held, and all movement is taken by the elasticity of the rubber.

It will be obvious that the rubber cannot stretch indefinitely, and it is equally clear that to give satisfactory results the "Silentbloc" bush should be so positioned that in service the deflections and strains imposed upon the rubber are reduced to a minimum.

To remove bronze bush from spring eye, either remove spring complete and use a press, or obtain a piece of steel tubing about $2\frac{1}{2}$ in. long, having an internal bore diameter greater than 1 in.

A bolt long enough to pass through the spring eye and this bush, and threaded for a considerable distance down its length, is also required. The bolt is then used to draw the bush into the tubing, as shown in Fig. 5.

Attention to Leaf Springs

Periodically, attention should be given to the leaves of the springs themselves, in regard to the following details :

(1) The car should be jacked up so that the weight is no longer taken on the road springs. Any road mud should be scraped off the outside of the blades and the blades thoroughly cleansed with paraffin. It will then be found possible to spray the springs with penetrating oil. This will provide a satisfactory lubricant for the spring leaves.

(2) *Alignment of the Leaves*

Periodically, and particularly when the car is new, the road springs should be examined to see that the leaves lie in line. To align the leaves, clips are riveted to certain of the blades, and these are held over the top leaf by means of a nut and bolt.

The short, lower leaves can, however, become slightly deranged. To correct this the U-bolts securing the spring to the axle should be slackened and the blades tapped with a hammer into their correct positions. Re-tighten U-bolts.

(3) After a considerable amount of usage a stiffening of the suspension system will possibly be noticeable, and this is due to the fact that the

normal radius ground on the end of each leaf is worn so that one leaf is digging into the underside of the leaf immediately above it. Such a condition will, of course, tend to damp the action of the spring.

It can be satisfactorily overcome if the springs are dismantled, the ends of the blades ground to a radius, the whole being reassembled with a liberal coating of white lead, oil, and flake graphite. Equal parts of each constituent should be taken and mixed together to the consistency of a paste.

To Dismantle and Rebuild Road Springs

Before dismantling, mark one end of each leaf with a centre punch in the case of the rear springs. This ensures that the blades are replaced in the positions occupied before dismantling, as these springs are symmetrical. Remove the spring from the chassis frame.

Hold the spring leaves together in a press and remove the dowel bolt. Release the press gradually and remove the lower leaves. Hold the upper leaves together in the press, remove the bolts from the clips on the longer leaves and dismantle the longer leaves.

To rebuild the road spring a length of $\frac{5}{16}$-in.-diameter rod should be threaded through the dowel hole before the leaves are compressed. Having compressed the leaves, the dowel bolt can then be fitted and the spring rebuilt. Before rebuilding the spring, lubricate and overhaul the leaves as recommended in notes given above.

To Replace Front Spring

Fit the bronze bush to the front end of the spring and the "Silentbloc" bush to the rear end of the spring. Both these bushes can be drawn into position by means of the long bolt from the tubular extractor, the rear "Silentbloc" bush being finally centralised by using the tubular portion as a packing piece under the nut of the bolt.

Fit the rear shackle to the spring, but do not tighten the bolt. Place the spring in position over the axle and the steel distance piece or bush in the front spring eye. Place thrust washers on either side of the front spring eye. Refit to the chassis frame. Place the shackle bolt in position and tighten the nut fully.

The end float on this assembly can then be checked. There must be no question of stiffness, but the float must not be more than ·003 in.

Build the rear shackle to the "Silentbloc" in the chassis bracket, but do not tighten the shackle bolt.

Secure the spring to the axle, fitting the rubber buffer clip under the U-bolts and the metal wedge between the spring and axle, the thickest portion to the front. Tighten the U-bolts as far as possible. Place jacks under the axle and remove the jack from below the chassis.

Load the chassis by putting excess weight on the front end. Tighten the U-bolts between the spring and axle only when the spring is fully compressed.

Release the front of the chassis frame. Obtain a length of steel to act as a gauge, measuring exactly $4\frac{3}{8}$ in. long. Other suitable dimensions would be 1 in. by $\frac{1}{8}$ in. thick. Place this gauge just in front of the U-bolt on the spring and load the chassis until this distance piece is nipped between the spring and the lower horizontal face of the frame. Only when the spring is so compressed, tighten the rear shackle bolts.

To Replace Rear Spring

Fit the " Silentbloc " bushes to both spring eyes. Fit the rear shackle, but do not tighten the bolt. Refit the spring to the chassis frame..

Place the front and rear shackle bolts in position, but do not tighten the bolts. Secure the spring to the axle.

Obtain a length of steel to act as a gauge, measuring exactly $5\frac{3}{8}$ in. long. Other suitable dimensions for this gauge would be 1 in. by $\frac{1}{8}$ in. thick. Place the gauge on top of the rear axle and load the car until the gauge is nipped between the axle and the lower horizontal face of the frame. Only when the spring is so compressed, tighten the shackle bolts.

REPAIR NOTES ON THE FIAT MODEL-500 CAR

REAR AXLE, SPRINGING, STEERING, BRAKES, AND BODYWORK

REAR AXLE

Removing Rear Axle

JACK up the rear end of the car and place supporting stands under the chassis side members. Disconnect the rear flexible coupling of the propeller shaft. Remove the wheels.

Disconnect the pin of the left torque arm ; the pin of the rear left road spring ; the fork-lever pin of left-side shock absorber ; the union of the rear hydraulic brake hose ; the pin of the right torque arm ; the pin of the rear right road spring ; the fork-lever pin of right-side shock absorber.

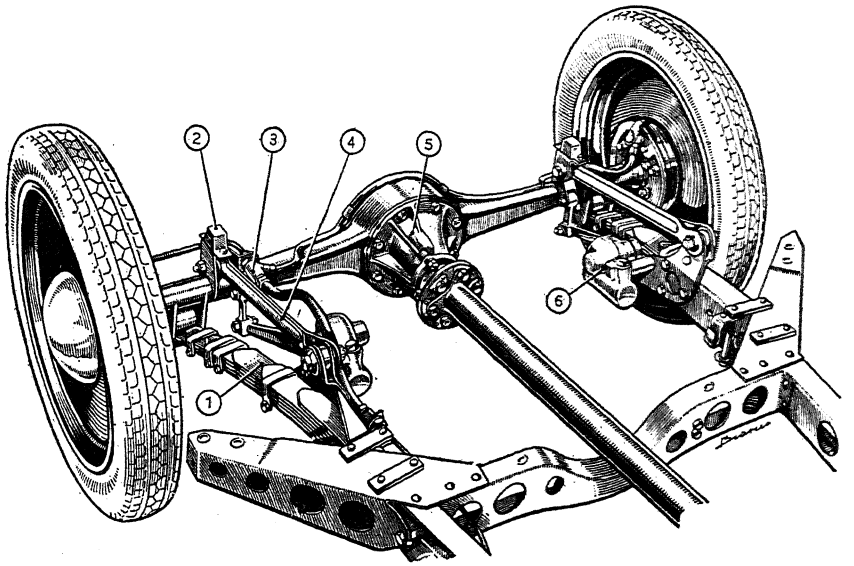


Fig. 1.—REAR OF CHASSIS UP TO CAR NO. 046000

1, Semi-cantilever spring. 2, Buffer blocks. 3, Three-way union for brake fluid. 4, Reaction and thrust arm. 5, Differential casing. 6, Hydraulic shock absorber.

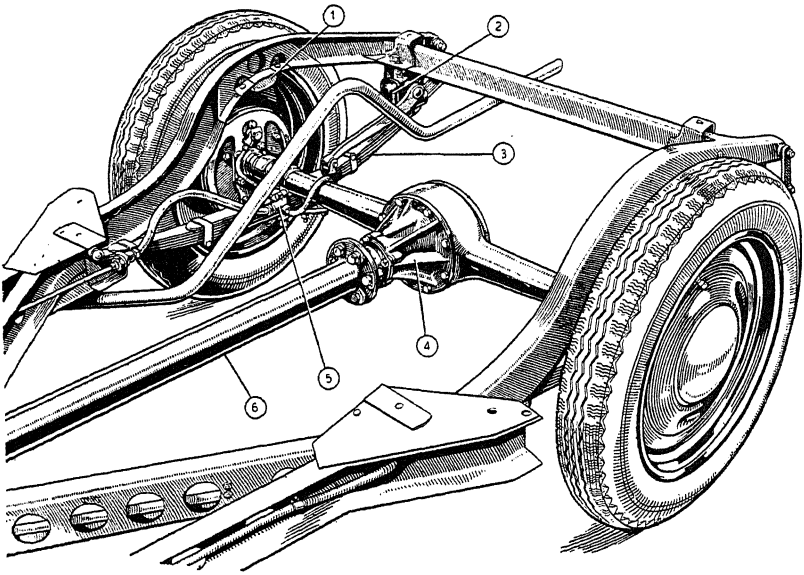


Fig. 2.—REAR OF CHASSIS (PRESENT TYPE)

1, Rubber buffer. 2, Hydraulic shock absorber. 3, Cantilever spring. 4, Differentia rrier. 5, Three-way union for the hydraulic braking system. 6, Propeller shaft.

Unscrew the bolts fixing the rear ends of the rebound straps and remove the rear axle from the car.

Dismantling the Rear Semi-cantilever Springs, with Rear Axle Removed

Up to car No. 046000, the chassis rear portion is different from that of the present-type chassis. The side members are shorter than in the present type, so as to allow the fitting of the semi-cantilever springs of the special suspension. These springs are fixed to the frame and are articulated at the end fastened to the rear axle casing (Fig. 1). Furthermore, a tubular arm, fastened to the frame and the rear-axle casing, forms a parallelogram which takes up thrust and torque. To loosen the bolts fixing the springs to the chassis side members, remove the cross-bolt supporting the front end of the spring, the spring individual packing block, and then remove the springs.

Dismantling the Rear-axle Unit

Pull off the hubs with brake drums from the driving shafts, having first removed the split-pins and the nuts, using a drawer. Remove the brake-housing flanges complete.

Pull out the driving shafts, using a drawer. Unscrew the bolts fixing the differential carrier to the rear-axle casing, and remove the differential unit.

SPECIAL REPAIR TOOLS FOR THE FIAT-500 MODEL

The following gives a complete list of the special tools available for dealing with the Fiat-500 model, including engine, clutch, and gearbox.

A. 6506. Draw bolts for the cylinder head.
A. 6507. Drawer for the valve-gear driving pinion.
A. 6508. Extension for the drawer A. 6450 for the differential driving shafts.
A. 6509. Drawer for the differential inner box roller bearing.
A. 6510. Drawer for the wheel hubs.
A. 6511. Drawer for the roller-bearing outer rings of the front wheels and propeller shaft pinion.
A. 6512. Tool for dismantling the rear-bearing inner ring of propeller-shaft pinion.
A. 6513. Puller for removing the steering arm.
A. 6514. Puller for the steering-worm roller-bearing inner rings.
A. 6515. Puller for the clutch-shaft roller bearing.
A. 8061. Spanner for adjusting the tappets.
A. 8062. Spanner for adjusting the tappets.
A. 8063. Spanner for sparking plugs.
A. 8064. Spanner for the cap fixing the dynamo driving pulley.
A. 8065. Spanner for the steering-worm thrust-bearing sleeve.
A. 8066. Spanner for the primary and direct-drive shaft locking ring.
A. 8067. Wrench for the secondary-shaft locking ring.
A. 8068. Spanner for dismantling and reassembling the starter motor.
A. 8069. Spanner for the screws that fix the fork levers on the striker rods.
A. 8070. Spanner for the wheel hub caps.
A. 10105. Lathe mandril for skimming up the front-wheel brake drums.
A. 10106. Lathe mandril for skimming up the rear-wheel brake drums.
A. 10107. Lever for dismantling and reassembling the valves.
A. 10108. Tool for fitting the pistons.
A. 10109. Tommy bar for assembling and dismantling the valve guides.
A. 10110. Tool for dismantling the steering-box oil seal.
A. 10111. Tool for dismantling the steering-box rear roller-bearing outer ring.
A. 10112. Tool for dismantling, assembling, and adjusting the clutch.

A. 10113. Ring for withdrawing the ball bearings of the differential shafts.
A. 10114. Clips for fitting the piston rings.
A. 10548. Plate for fixing the gearbox to the overhauling stand A. 10534.
A. 10549. Plate for fixing the differential group to the overhauling stand A. 10536 bis.
A. 11210. Hand-operated cylinder grinder.
A. 11439. Expanding pilot for refacing the valve seats.
A. 11440. Cutter for refacing the valve seats.
A. 11441. Cutter for reducing the valve-seat width.
A. 11443. Testing apparatus for valve leak.
A. 11444. Wire brush for the valve guides.
A. 11469. Conical grinding stone for refacing the valve seats, with the " Vibrocentric " apparatus.
A. 11475. Valve-refacing chuck for the " Vibrocentric " apparatus.
A. 11518. Blade for the IC-type " Ammco " apparatus for crankshaft-journal regrinding.
A. 11606. Chuck for refacing the crankshaft bearings.
A. 11607. Blade range for the chuck A. 11606—for refacing the rear bearing.
A. 11608. Blade range for the chuck A. 11606—for refacing the front bearing.
U. 0200. Reamer for the connecting-rod bearings.
U. 0315. Tool for valve cleaning.
U. 0326. Expanding reamer for gudgeon-pin holes.
U. 0386. Expanding reamer for the pin holes of the steering knuckles and swinging arms.

Equipments

Arr. 2009. Hook for hoisting the car both ends.
Arr. 2027. Hydraulic jack for lifting up the car.
Arr. 2205. Clips for fixing the engine on overhaul revolving stand.

Gauges

C. 641. Drum for testing the centring of the front- and rear-wheel brake shoes.
C. 642. Graduated quadrant for timing the engine.
C. 643. Gauge for the cylinder bores.
C. 644. Gauge for checking over the steering knuckle joints to the pillars.

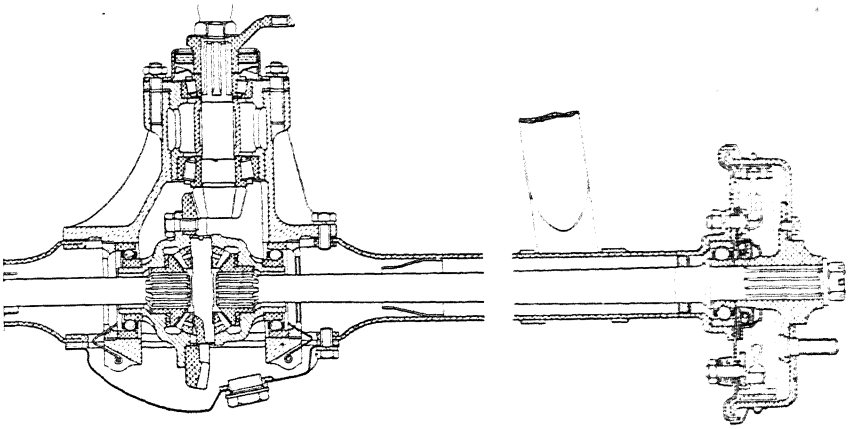


Fig. 3.—SECTION THROUGH REAR AXLE AND WHEEL HUB

Remove the split-pins and the clips of the differential assembly : the bearing caps, the locking plates, and the inner box ; the transmission-shaft rear joint ; and the bevel-pinion group.

Dismantle the bevel-pinion group ; if required, the crown-wheel, and then the planetary and satellite pinions.

To adjust the bevel-pinion roller bearings, add or remove the packing washers which are used in conjunction with distance-piece.

To move the bevel pinion backwards or forwards, add or remove the packing plates.

The side movement of the differential inner box and the bearings play adjustment are effected by actuating the locking rings after having lifted the retaining clips.

The bevel group has a toothed crown-wheel with a clockwise spiral, and a toothed pinion with an anti-clockwise spiral.

Reassembling

Repeat the same operations in a reverse order as for dismantling.

The pins of the torque arms as well as the pins of the arms of the shock absorbers must be set while the car is under static load.

FRONT SPRINGING

Removing the Unit from the Car

Remove the radiator. Jack up the front portion of the car, placing the stands under the side members of the frame.

Remove the wheels ; the pins of the semi-elliptic spring ; the four bolts fixing the spring central clamps ; the four bolts fixing the wings to

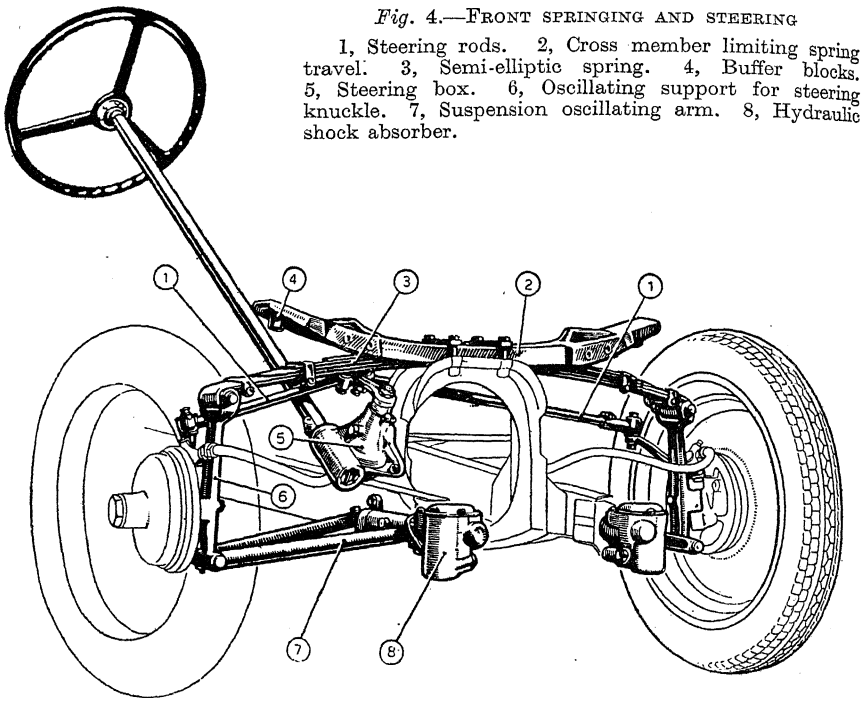


Fig. 4.—FRONT SPRINGING AND STEERING

1, Steering rods. 2, Cross member limiting spring travel. 3, Semi-elliptic spring. 4, Buffer blocks. 5, Steering box. 6, Oscillating support for steering knuckle. 7, Suspension oscillating arm. 8, Hydraulic shock absorber.

either side of the buffered cross-member ; the two bolts with spacer fixing the cross-member to the side members of the frame ; and the cross-member with the spring.

Disconnect the steering rods from the steering knuckles ; the unions of the control pipes of the front hydraulic brakes ; and the swinging-arms unit, the wheel hubs, the hydraulic shock absorbers, etc.

Dismantling the Front Springing Assembly

Remove the wheel hubs with brake drums. Later, if it is necessary dismantle the roller bearings outer rings.

Dismantle the brake-housing flanges, complete, unscrewing the bolts by which they are fixed to the steering knuckles ; the steering rods, and disconnect them from the steering knuckles.

Withdraw the steering-knuckle pins, after having removed the split-pins from the pillar ; the pins connecting the pillars of the swinging-arms unit to the swinging arms ; and the pins of the swinging-arms supports on the side members of the chassis frame.

Reassembling

Repeat the operations in reverse order as described for dismantling.

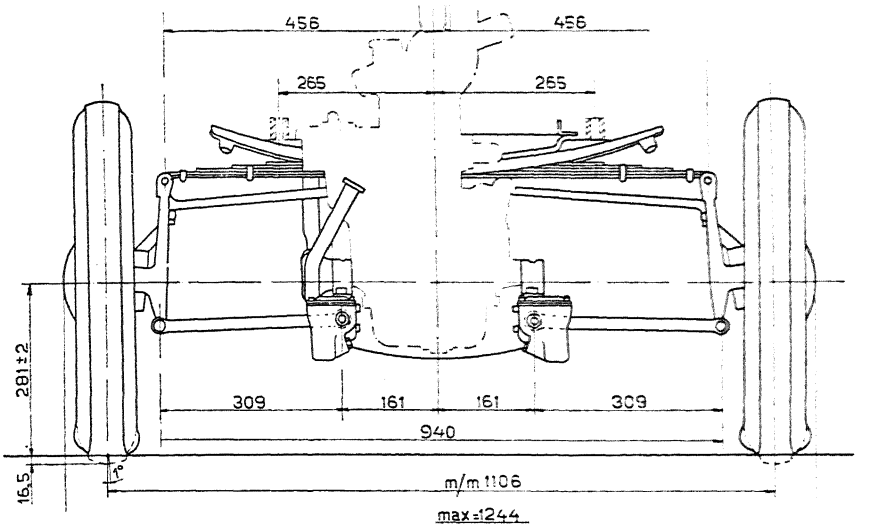


Fig. 5.—FRONT VIEW OF THE FRONT SPRINGING, SHOWING DATA FOR CARRYING OUT THE PRINCIPAL TESTS TO BE PERFORMED WITH THE CAR UNDER STATIC LOAD

Track 1,106 mm. (3 ft. $7\frac{7}{16}$ in.). Maximum width of chassis, 1,244 mm. (3 ft. $11\frac{3}{16}$ in.)

STEERING KNUCKLE AND FRONT SUSPENSION PILLAR

Make sure that the clearance between the bush located in the knuckle and the pin does not exceed 10 mm. (·004 in.).

Between the knuckle and the pillar, with their distance- and thrust-rings, the play should not exceed ·15 mm. (·006 in.).

The checking over of the suspension pillar is particularly important. Even small pillar deformations may noticeably influence the inclination of the wheels.

Checking over the " Toe-in " of the Front Wheels

Measure the distance between the insides of the front wheels from tyre edge to tyre edge both in front and behind their centres. The distance behind should be the greater by a margin of between ·12 in. and ·16 in. (3 to 4 mm.).

This test should be carried out with the car under static load.

To adjust the wheel convergence, disconnect the longer steering rod, and vary its length, according to requirements, by adjusting the sleeves at the ends.

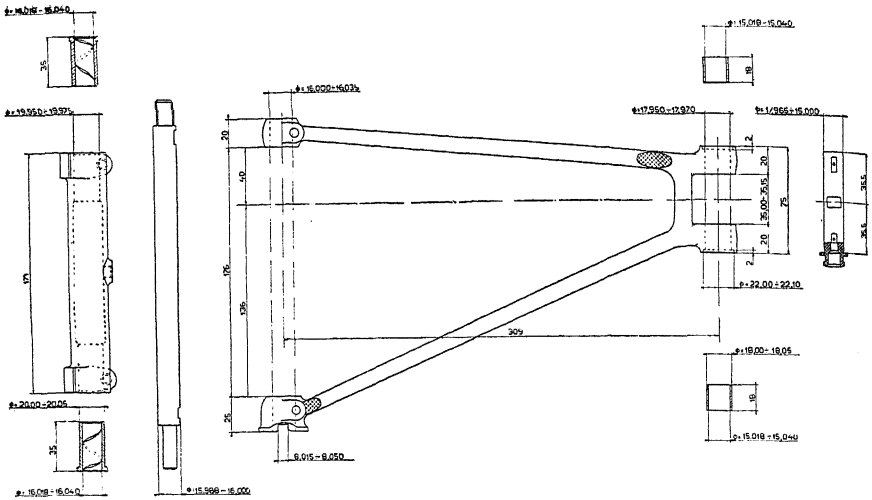


Fig. 6.—MAIN DATA FOR CHECKING OVER THE FRONT SUSPENSION SWINGING ARMS WITH THEIR PINS AND BUSHES

See that the pins are exactly parallel and lie in the same plane. The maximum clearance allowable between the bushes and the pins is 0·15 mm. (·006 in.).

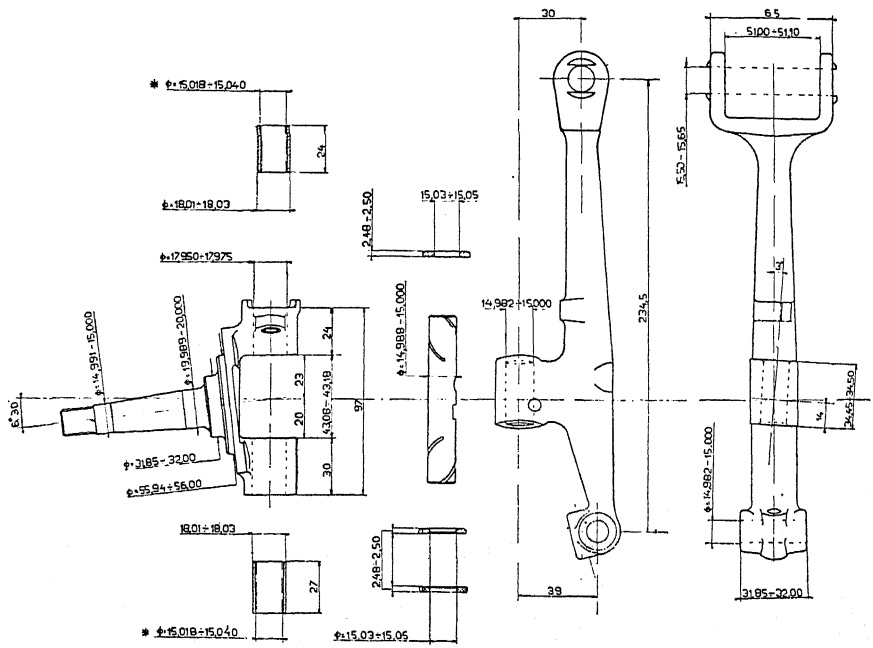


Fig. 7.—MAIN DATA FOR CHECKING OVER BOTH THE STEERING KNUCKLE WITH ITS PIVOT PIN AND THE FRONT SUSPENSION PILLAR

Checking over the Inclination of the Front Wheels

The front wheels have an outward inclination of about 1° from the vertical, which is equal to approximately ·12 in. at the tyre edge. Checking must be carried out with a laden car.

Should an undue inclination be observed, check over the whole of the front suspension, about which are supplied data with the figures.

The angle of the car longitudinal pitch should be 9°. Should there be any doubts of this, check over the individual parts of the suspension.

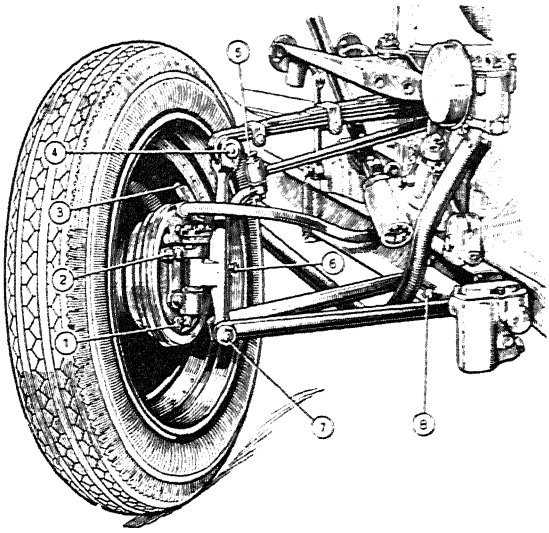


Fig. 8.—DETAIL OF ONE FRONT WHEEL

1, Cam for adjusting clearance between brake shoe and drum. 2, Bleeder screw in hydraulic brake-fluid piping. 3, 4, 5, Grease-gun nipples. 6, Brake-shoe pivot pin. 7, 8, Grease-gun nipples.

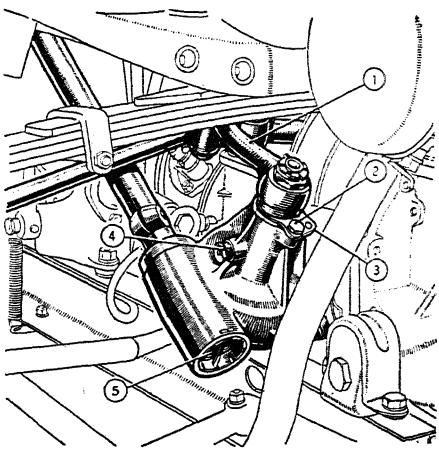


Fig. 9.—ADJUSTMENT OF STEERING WORM GEAR

1, Steering arm. 2, Screw holding adjusting plate in position. 3, Adjusting plate for play between quadrant and worm. 4, Grease-gun nipple. 5, Ring for regulating play in worm roller bearings.

STEERING RODS

One of the two steering rods—the longer one—has adjustable terminal sleeves, which can be unscrewed or screwed up to adjust the front-wheel convergence.

Inspect the condition of the ball joints and the concave bearings. The working surfaces should be quite smooth, without pits or roughness. Should they not be so, they should be replaced by new ones. The ball pin should also be replaced if the head tends to become oval owing to wear, or if the pin-threaded portion appears worn.

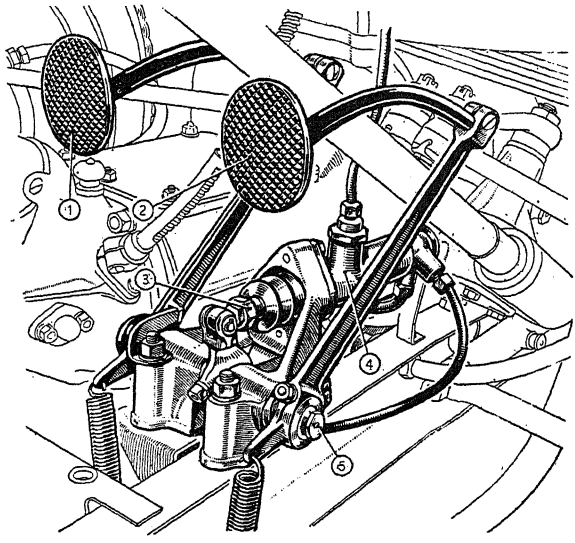


Fig. 10.—DETAILS OF PEDALS AND HYDRAULIC BRAKE CYLINDER

1, Clutch pedal. 2, Hydraulic brake pedal. 3, Nut and locknut for adjusting hydraulic brake-cylinder piston tappet and consequently the free travel of the brake pedal. 4, Hydraulic brake master cylinder. 5, Grease-gun nipple.

Also make sure that the springs still retain their tension, otherwise they should be replaced with new ones.

STEERING

Removing the Steering from the Car

Jack up the front end of the car. Remove the left-side front wheel; the engine left-side under-tray; and the split-pin and the nut fixing the steering arm. Pull off the steering arm.

Dismantle the steering column together with the steering wheel, disconnecting the electric-horn cable and removing the worm sector fixing bolt, together with the cap of the support securing the steering column to the fascia board. Remove the steering unit from the car.

Dismantling the Unit

The operations for dismantling the unit are quite simple, and the work may be rendered easier by using special tools.

Inspections and Adjustments

Closely inspect the working surface of steering worm and worm sector, which should be perfectly smooth, having no pits nor roughness.

It is also necessary to make sure, from an examination of the worm and teeth contact surfaces, that the steering worm and worm sector engage in a proper and central position in order to be able to effect the required adjustments when reassembling.

Check over the play between the eccentric bush and the worm-sector spindle. It is allowed a maximum play of ·10 mm. (·004 in.).

Make sure that the steering worm is running true: the maximum allowable tolerance is ·05 mm. (·002 in.).

Excessive play between the steering worm and worm sector is

corrected by turning the eccentric bush carrying the sector spindle, proceeding as follows :

Take down the steering arm and its packing.

Remove the screw holding the adjusting plate, turn the eccentric bush by means of the adjusting plate so as to bring the sector nearer to the worm and at such an angle as to make it possible to fix the adjusting plate again through the second hole.

Should the adjusting plate be already fixed at the second hole and consequently, by turning it, it is no longer possible to fix it in position again, it must be taken off the bush and replaced one notch farther round.

Play in the roller bearings of the worm is taken up by means of the screwed ring situated on the end of the steering box.

Should the steering worm and worm sector not engage centrally, it is possible to move the worm-sector spindle sideways by adding or taking off distance-rings on the eccentric-bush union, after which the lateral play can be adjusted by means of the square-headed screw.

The foregoing adjustments must be made in such a manner as to eliminate all play in the steering column, without, however, making the steering too stiff.

RADIATOR

Removing the Radiator from the Car

Take off the shell with the front grill. Open the tap located on the cylinder-block front, to drain the water from the radiator and the cylinder-block jackets. Disconnect the rubber hose for the radiator water inlet and outlet. Remove the bolt fixing the tie-rod on the upper part of the radiator and the two bolts fixing the lower part to the chassis cross-member. The radiator is then free and can be removed.

Repairing the Radiator Core

It is easy to detect and repair leakages in the outer-range tubes, but it is not so easy to find the exact spot where the leakage originates with inner-range tubes, so that it is sometimes advisable to substitute a new radiator core.

To eliminate small leakages, heat the part concerned with a blow-lamp, taking precaution to keep the flame moving to avoid burning the pipes. It is thus possible to create an opening among the blades, bending down the lower ones and lifting the upper ones around the leakage which is then exposed to view, and the faulty tube can be repaired.

For radiator outer repairs any soldering iron can be useful, but for repairs to inside tubes a small soldering iron, flat enough to pass between the tubes, should be used. The surface around the leakage can then be tinned, and the leak repaired. The spot to be soldered should be previ-

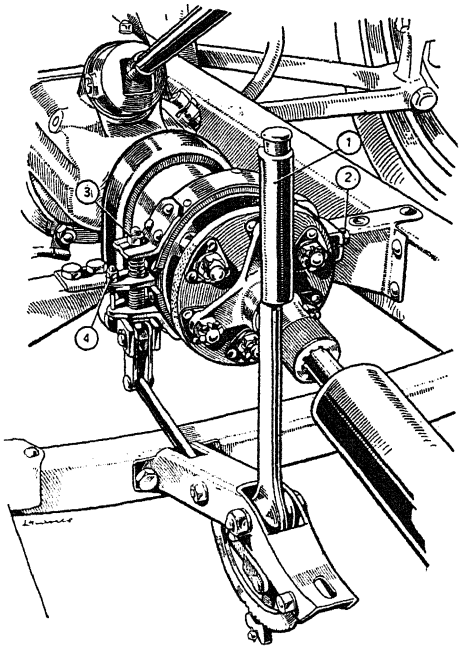


Fig. 11.—TRANSMISSION BRAKE

1, Control lever. 2, Screw for centring brake band. 3, 4, Nuts of pull rod for adjusting clearance between brake band and drum.

ously cleaned with acid. The soldering apparatus or the iron should be used moderately hot, and should be withdrawn early enough to prevent its adhesion to the tubes.

For these repairs 50/50 solder preparations should be used. (Tin and lead to be united into alloy should be first-fusion metals, without any traces of antimony or other impurities.)

When the soldering has been effected, the blades should be straightened.

BRAKES

The wheel brakes are of the hydraulic Lockheed type, and are controlled by the brake pedal. The transmission brake is composed of a drum and band, and is controlled by a hand lever.

Inspections and Adjustments

With regard to the wheel brakes, make sure that the drums are well centred; the maximum tolerance allowed being ·10 mm. (·004 in.).

As to the transmission brake drum, it should be perfectly centred and balanced. Between drum and brake band there should be an equal clearance all round, measuring about ·50 mm. (·02 in.).

The brake-shoe pivots are not eccentric, so that any necessary adjustment to the shoes should be effected through the upper eccentrics, and the clearance between the drum and the linings brought to about ·25 mm. (·01 in.).

If for any reason the free movement of the pedal is less than ·24 to ·27 in. (6 to 7 mm.), adjust the push-rod clearance by means of the adjusting nuts.

The adjustment of clearance between the transmission brake drum and the brake band is made by first using the screw shown on the right side of Fig. 11, and then on the pull-rods shown on the left of the same figure—at the ends of the brake band.

BODY OVERHAULING

Removing from the Chassis

Remove the front of bonnet, with grill of dummy radiator shell ; the front curved member, connecting the front wings. Drain the radiator and cylinder-jacket water. Dismantle the carburettor, disconnecting the starting-device control wire, the petrol pipe, the accelerator control rod, and loosening the nuts which fix the carburettor to the manifold. Disconnect the oil-gauge pipe from its union on the crankcase.

Remove the radiator. Disconnect the starter-motor switch wire. Jack up the front end of the car. Remove the left front wheel.

Disconnect the hydraulic brakes master-cylinder pipe, taking care to collect the brake fluid in a vessel ; the engine side undertrays ; and the speedometer cable from the gearbox.

Remove the clutch and brake pedal-actuating lever, and the transmission brake-control hand lever. Disconnect the clutch control rod. Unscrew the gear lever. Remove the steering column and wheel.

Disconnect the battery ; the headlamp, tail- and signal-lamp cables ; the dynamo and starter-motor cables ; and the ignition distributor leads.

Fit the left front wheel, lower the front end of the car, and jack up the rear end.

Disconnect end of the bodywork retaining fabric (i.e. rebound straps) so that the rear axle becomes free. Lower the car. Remove the seats. Pull out the carpets.

Remove the bodywork inner side coverings under the dashboard. Loosen all the bolts fixing the bottom floor framework to the chassis and those fixing the bodywork to the side brackets. Lift up the body slowly, taking care that no fixing bolt has been overlooked.

It is possible to lift up the body by hand. Four men are enough.

Reassembling the Body on the Chassis

Place the body on the chassis, taking care that the bolt holes register correctly and that the tarred-hemp pads are in their proper places. Then insert all the bolts without tightening them thoroughly. Insert the four bolts fixing the body on the cross-member and those two for which a distance-piece is supplied with each.

Jack up the front end of the car to fix the body on the front brackets after fitting the distance-pieces. Then jack up the rear end of the car to fix the body on to the rear brackets. Connect the rebound straps. Lower the car. Tighten all the fixing bolts. Fix the carpets, the inner side coverings of the body, and the seats ; the front curved member connecting the front wings.

Jack up the front end of the car. Disconnect the left front wheel. Connect the brake pipes to the master cylinder. Fit the brake and clutch-

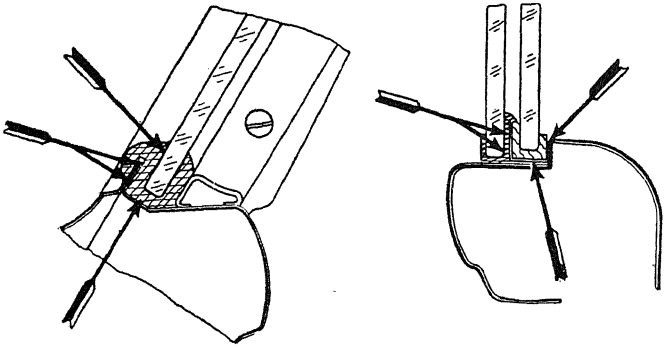


Fig. 12.—THE ARROWS INDICATE THE SPOTS TO WHICH THE CEMENT SHOULD BE APPLIED IN ORDER TO ELIMINATE WATER LEAKAGES

pedal levers; the steering column and steering wheel, and the transmission brake and the gear lever.

Refit the left front wheel, and then lower the car. Fit the radiator, and the carburettor, together with the control rod and the petrol pipe.

Reconnect the oil-gauge pipe ; the starter-motor control cable ; the speedometer cable to the gearbox ; the battery, connecting again the dynamo, starter motor, headlamps, tail and signal lamp, and the ignition distributor leads.

Bleed the hydraulic brake system.

Make sure that everything is in order, then refill the radiator and the brake-fluid reservoir. Fit the front of bonnet.

POSSIBLE TROUBLES WITH SALOON-CAR BODYWORK

Water Leakages

Water leakages in a car may originate from :

(*a*) Cement drying too quickly or from an imperfect adhesion of the framework to the channels, particularly at the lower corners of the front or rear glass frameworks. (The latter applies only to fixed-head saloons.) Water leakages may occur, too, between the door panels and the channels of the fixed or movable glasses.

Remedy.—Find out the exact leakage spot, bearing in mind that the leakage may originate in quite other places than those apparently concerned. Then apply some cement—as indicated by the arrows on Fig. 12—and make sure of the perfect adhesion of the framework.

(*b*) A deterioration of the rubber packing of the windows, probably brought about by the petrol used in cleaning the glasses.

Remedy.—Replace the rubber packing.

(*c*) Water leakages may also occur between the dashboard and the front side panels of the bodywork, as the water may come in unimpeded through the ventilation slots in the upper flaps of bonnet.

Remedy.—In the outer and lower corners of the dashboard, at the connection with the panels, there are points where filling-plaster is used

instead of rubber packing. Make sure that the plaster is still in place and not cracked or chipped. If found to be faulty, apply a new filling plaster.

Noisy Doors

Door rattles may be traced back to :

(*a*) Registers being loosened, not aligned, and not fitting in their housings.

Remedy.—Tighten the screws fixing the door registers or replace them with oversize ones if their seat thread has become worn. Under the steel housing of the rubber blocks in the striker plate add—as required—taper or flat pads to re-establish the alignment.

(*b*) Unequal clearance between door and door frame.

Remedy.—Make sure that there is a 3-mm. ($\frac{1}{8}$-in.) minimum clearance all round between the door and the door frame, both internally and externally.

(*c*) Excessive play in the latch.

Remedy.—Particularly correct the play between the latch tongue and the lock wall, punching the latter as necessary.

(*d*) Excessive play between the latch tongue and the rear wall of its catch-plate.

Remedy.—Replace the catch-plate with another 1 or 2 mm. (·04 in. to ·08 in.) longer—according to need.

(*e*) Rubber buffer at bottom of rear pillar insufficiently compressed when the door is closed.

Remedy.—Add a rubber or metallic washer under the buffer, or substitute a harder or slightly higher buffer for the old one.

Noisy Windows

The door windows may become noisy for the following reasons :

(*a*) Excessive play between the glass and its felt channels, owing to the felt getting worn.

Remedy.—Replace felt channel altogether.

(*b*) Excessive play between the glass and the felt channel, owing to the metal framework of the channel being too wide.

Remedy.—Press the edge of the metal channel slightly downwards, from inside the car, taking care that the surrounding framework is still adhering to it.

(*c*) Excessive play between the glass and the upper and lower channels.

Remedy.—Add cardboard or fibre packing between the channel and the door rail.

(*d*) The sliding glass knob becoming slack.

Remedy.—Add leather or imitation-leather washers, so glued that they register it properly on the guide. Then tighten the screw securely.

(*e*) The glasses rattle against the heads of the channel fixing screws.

Remedy.—Try countersinking the screw heads, so that these remain

completely sunk in the felt. But if the felt gets irreparably damaged replace the channel completely.

Squeaking

Squeaks may emanate from :

(*a*) The flaps of the bonnet against the edges of the cowl.

Remedy.—Reduce the height of the flap flanges to correspond with the cowl closure edges, and fit below some rubber buffers or one or two 1-mm. washers.

(*b*) The dummy-radiator shell.

Remedy.—Find the spot where the edges of the dummy-radiator shell overpass the rubber packing touching the bodywork, and remove some of the material.

Dust Penetration

The penetration of dust may be caused by :

(*a*) The rubber draft excluder which runs round the door frame having got out of shape or loose.

Remedy.—Replace the rubber draft excluder with a new one having a wider projecting rim.

(*b*) The rubber draft excluder may have too much of its rim cut off along the bottom for draining the water.

Remedy.—Remove the lower part of the rubber draft excluder and replace it with another on which less of the rim has been removed.

(*c*) The sound-absorbing plaster has come off along the lower union flange of the bodywork.

Remedy.—Remove the carpets, so that it is possible to find out exactly where the dust gets in. Then fill up with filling-material or glued strips of imitation leather.

Doors Open while the Car is Running

(*a*) Latch alignment defective.

Remedy.—Loosen the screws, align the latch, and then tighten the screws.

(*b*) Excessive clearance between the latch and the catch-plate.

Remedy.—Add a packing plate 1 mm. thick under the catch-plate.

Jacking up the Car

To jack up the car, special hooks have been devised—Arr. 2009—which are applied to the tyres and then hoisted by means of a crane. These hooks are of use in jacking up the front as well as the rear end of the car.

After having lifted the car, place stands under the side members of the chassis frame.

LEYLAND VEHICLES

PROPELLER SHAFT OVERHAUL

When removing Gearbox

TO swing the front propeller shaft aside when removing the gearbox, uncouple the front coupling from the gearbox flange, slacken the four centre-bearing clamp-screws, release the lubrication pipe and unscrew the dowel locating the housing on the cross-member. The centre-bearing housing can then be moved along the cross-member until the shaft is clear of the gearbox and the front end slung conveniently. Do not allow the shaft to hang from the centre bearing.

Removal of Propeller Shafts

Before removing the front propeller shaft, the rear shaft must be removed. In all cases this can be disconnected at the flanges and lifted clear.

To remove the front shaft, take out the four centre-bearing clamp-screws, and remove the cap, release the lubrication pipe, disconnect the front coupling at the gearbox flange, and lift out the shaft and centre bearing together.

Dismantling Centre Bearing

Remove the propeller shafts as outlined above, take off the flange retaining nut (*D*), Fig. 1, and slip the flange off the splines. The inner

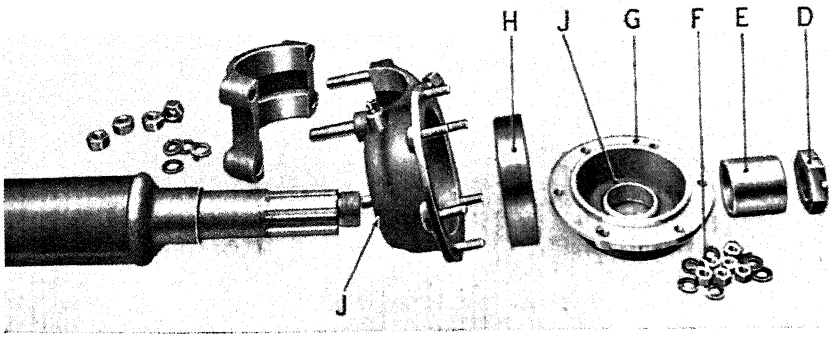


Fig. 1.—DISMANTLING CENTRE BEARING

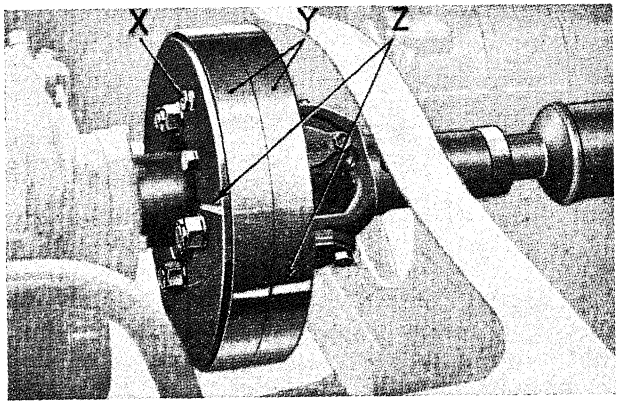


Fig. 2.—TRANSMISSION DAMPER

race is a push-fit on the shaft and is locked by pulling the flange up against a distance-sleeve (*E*).

Take off the nuts (*F*), Fig. 1, and remove the cover (*G*), the bearing (*H*) can then be knocked out of the housing, in which it is a press fit.

Oil loss is prevented by leather oil seals. These should be renewed if oil leakage is apparent.

If the bearing is to be renewed, knock the old bearing out of the housing and press in the new one.

The spherical-seating ring is not hardened, and care should be taken not to damage it in any way when pressing the bearing into the housing.

Reassembling Centre Bearing

Replace the bearing and housing on the shaft, taking care not to damage the oil seal, pack with grease and replace the cover. Slip on the distance-sleeve (*E*), fit the flange on the splines, and tighten the nut (*D*) hard, locking with the split-pin. When replacing the centre bearing on the cross-member, make sure the dowel screw is in position, and do not forget to connect up the lubrication pipe.

Couplings

All-metal needle-bearing Spicer couplings are used, or Leyrub couplings. Particulars concerning overhaul of these couplings are given in Vol. I.

Damper

On certain machines a friction-type damper is fitted in the transmission line. The damper is of simple construction and should require little attention beyond regular lubrication through the nipple (*X*), Fig. 2.

In the event of noise developing in the transmission, the damper should be checked for effective operation in the following manner.

Check that the loose rings (*Y*), Fig. 2, can be just moved by hand. If the rings are very loose the damper is not efficient, and the spring tension should be adjusted by packing the springs, or new liners should be fitted. The liners are $\frac{3}{16}$ in. thick when new. If the loose rings cannot be moved

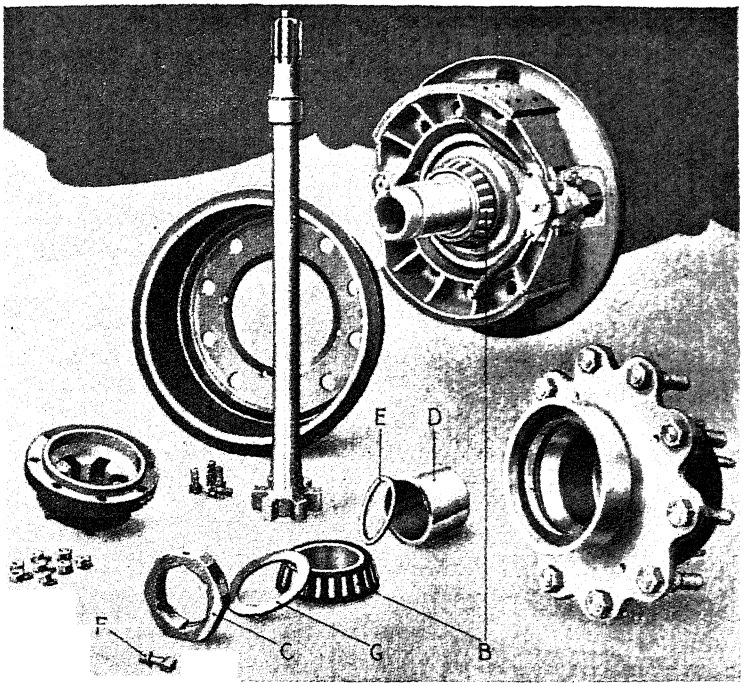


Fig. 3.—TYPICAL HUB ASSEMBLY

by hand the damper should be removed and the friction surfaces thoroughly cleaned.

A chalk mark (*Z*) should be made on the fixed plates and carried over the loose rings. If the machine is now run on the road, the relative movement of the damper plates will be shown by the position of the chalk marks. These should have separated as shown in Fig. 2. It should be noted that the period of oscillation will occur only round about one critical speed, and this speed must be gone through before the damper can be checked for correct operation. The critical speed varies from 20 to 30 miles per hour according to the type of chassis.

Removal of Damper

Disconnect the propeller shaft at the front coupling. Remove the companion-flange locking nut and draw off the flange. The damper is held together by two setscrews, and can be dismantled after removing these setscrews.

When reassembling the damper see that all the springs have been replaced, the dirt-excluding rubber ring placed in its slot, and that the spigot faces are clean and free from abrasions. *It is essential that the*

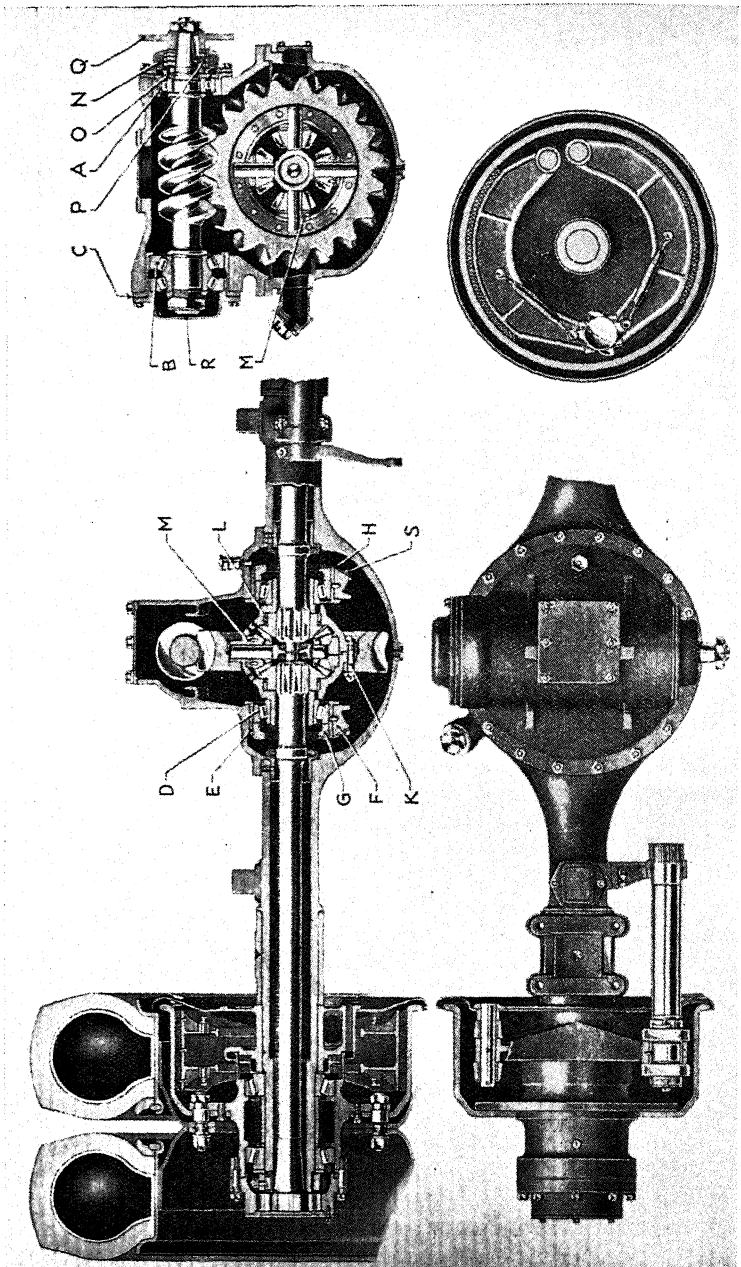


Fig. 4.—ARRANGEMENT OF OVERHEAD WORM REAR AXLE

A, worm shaft roller bearing. *B*, double taper-roller thrust bearing. *C*, shims for endwise adjustment. *D*, differential roller bearings. *E*, bearing cups. *F*, caps. *G*, adjusting nuts. *K*, alloy-steel bolts. *L*, bushes. *M*, renewable wearing pads.

damper runs perfectly true. Do not use a hammer to fit the damper on the spigot. The fixed plates are of light construction, and if these are distorted the damper will not operate effectively.

REAR AXLE

General Maintenance

The hub bearings should have end play of ·005 in., but this should not be allowed to become excessive. Check after the first 5,000 miles and adjust if play exceeds ·005 in., as outlined under "Adjustment of Hub Bearings."

Tighten the nuts round the worm carrier flange after 2,000 miles, and check periodically to prevent oil leakage. Check frequently that the spring-clip nuts are dead tight.

Withdrawal of Axle Shafts

Remove the nuts securing the hub cap, and draw off the hub cap by screwing jacking bolts into the tapped holes provided ; the axle shaft can then be withdrawn.

When replacing the hub cap make sure that the joint is in good condition and that the nuts are hammered tight ; they must not be just hand-tight.

Adjustment of Hub Bearings

The hubs are carried on taper roller bearings, mounted on the axle tubes. The bearings in each hub are secured by a large nut, a distance sleeve, and shim rings, enabling the desired adjustment to be obtained. The bearings are set by inserting suitable shim rings (available in various thicknesses), screwing up the nut and locking it with the locking bolt. The nut has six alternative positions for locking, and shim washers of various thicknesses are available to facilitate bringing the nut into the correct position for locking. It is important that the large nut be hammered tight ; on no account must it be slackened back to insert the locking bolt.

The bearings are correctly adjusted when the hub will rotate freely with approximately ·005-in. end play. Make sure that the locking bolt is split-pinned and the hub filled with grease before fitting the hub cap.

Adjustment of Worm Shaft

The worm shaft is carried in a roller bearing, the thrust being taken by a double taper roller bearing. Endwise adjustment is effected by means of shims fitted between the bearing housing flange and the cover ; shims are available in three thicknesses.

The worm shaft should have a minimum of ·007-in. end play. *This is important.* The correct clearance can be obtained by fitting the end cover with shims so that the worm shaft can only just be turned by hand.

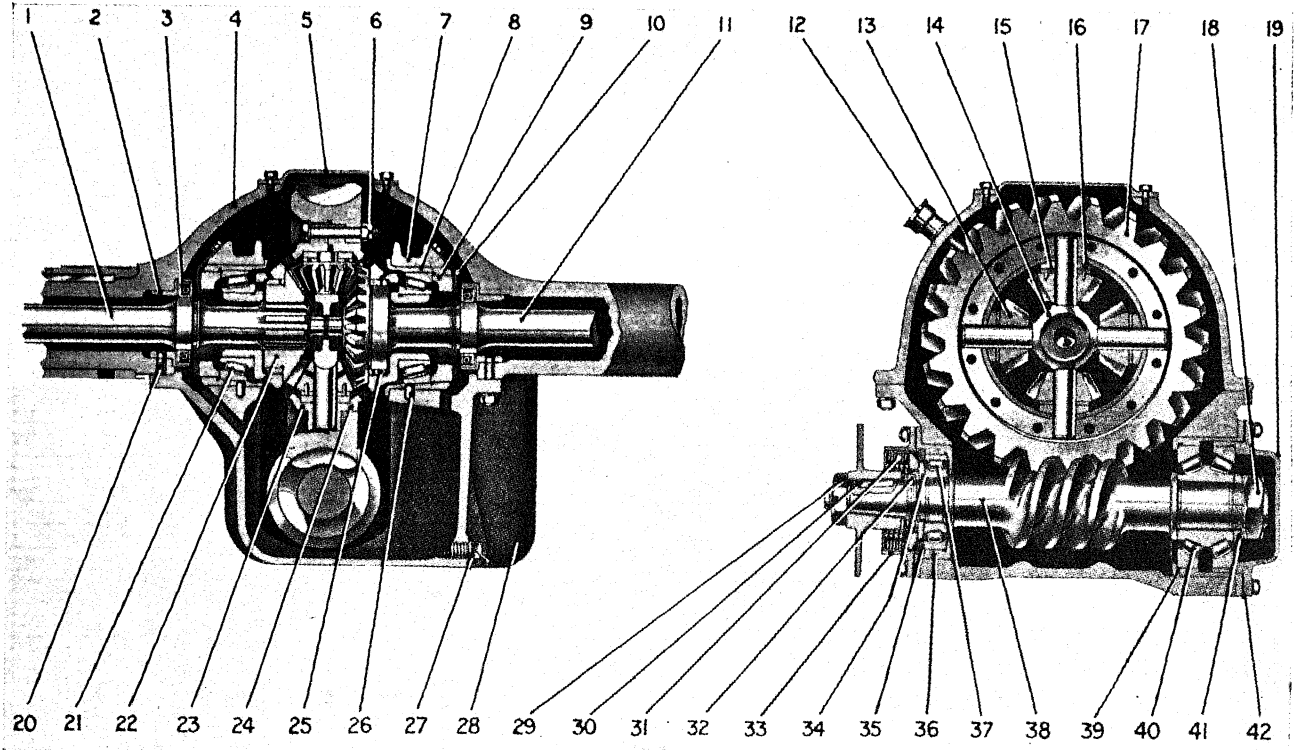


Fig. 5.—SECTION THROUGH UNDERSLUNG WORM REAR AXLE

1. Axle shaft (short).
2. Oil-seal housing.
3. Oil seal.
4. Axle casing.
5. Inspection cover.
6. Differential bolt.
7. Differential-bearing cap.
8. Differential-bearing cup.
9. Adjusting nut.
10. Locking plate.
11. Axle shaft (long).
12. Breather.
13. Differential pinion.
14. Differential spider.
15. Steel wearing plate.
16. Bronze wearing plate.
17. Worm wheel.
18. Rear-bearing nut.
19. Rear cover.
20. Oil-seal dowel screw.
21. Differential bearing.
22. Differential side pinion.
23. Serrated half diff. casing.
24. Spigot half diff. casing.
25. Side-pinion bush.
26. Bearing cup dowel.
27. Drain plug.
28. Worm carrier.
29. Coupling-flange nut.
30. Coupling-flange key.
31. Packless gland.
32. Worm-shaft nut (front).
33. Gland housing.
34. Gland-seating washer.
35. Shims.
36. Front-bearing housing.
37. Worm-shaft bearing.
38. Worm shaft.
39. Rear-bearing housing.
40. Rear bearing.
41. Rear-bearing washer.
42. Shims.

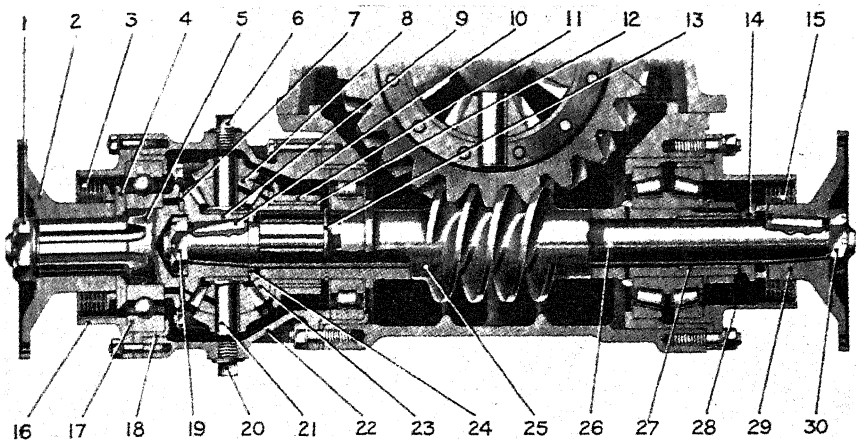


Fig. 6.—SECTION THROUGH THIRD DIFFERENTIAL

1. Coupling-flange nut (front).
2. Coupling-flange (front).
3. Packless gland (front).
4. Gland seating (front).
5. Splined half-differential case.
6. Oil plug.
7. Wearing washer.
8. Differential pinion.
9. Differential side pinion (front).
10. Key for side pinion.
11. Rear half differential casing.
12. Flanged bush.
13. Circlip.
14. Gland seating (rear).
15. Packless gland (rear).
16. Gland housing (front).
17. Ball bearing.
18. Bearing housing (front).
19. Nut for differential pinion.
20. Drain plug.
21. Differential spider.
22. Third differential casing.
23. Differential side pinion (rear).
24. Wearing washer.
25. Worm shaft.
26. Solid shaft.
27. Bush for solid shaft.
28. Gland housing (rear).
29. Coupling flange (rear).
30. Coupling-flange nut (rear).

The addition of one shim ·010 in. thick between the housing and cover will then give the desired running clearance. The adjustment should be carried out with all bearings in a clean and dry condition.

Adjustment of Differential Side Bearings

The differential roller bearings are carried in bearing cups which are split to nip the bearings when the caps are pulled down. The bearing cups are dowelled into the housing to prevent rotation when the adjusting nuts are tightened up. The adjusting nuts are locked by the locking plates fastened to the caps by setscrews.

The side bearings should be adjusted so that there is ·008-in. end play. Undue clearance results in a noisy axle and excessive wear of the worm wheel.

Ordinary running adjustment should be made on the left-hand (or nearside) bearing, which does not alter the alignment of worm and wheel. Do not disturb the right-hand bearing except when dismantling for overhaul or renewal.

Removal of Worm Wheel (Overhead type)

Remove bearing caps and lift the differential assembly clear of its bearings. The roller races and adjusting nuts will then draw clear.

The worm wheel is bolted to the differential casing by alloy-steel bolts fitted in reamed holes ; the bolts project through the nuts and are wired together, as are the bolt heads.

To remove the wheel, press from the differential casing and the differential gears can be removed. The wheel has teeth formed on the recess which engage with corresponding teeth on the differential casing. There is a slight interference as the wheel is pressed on, which ensures a metal contact and a good fit. The wheel is aligned on the differential casing by a spigot.

The bushes on the side differential pinions are fully floating and are made a very slack fit to avoid seizure. Three $\frac{5}{16}$-in. holes are drilled through the differential side cases to facilitate removal of the roller races. Renewable wearing pads are fitted behind the differential pinions.

Reassembling Differential

When assembling, see that all index marks coincide and that the contact faces are perfectly clean. The worm wheel must be pressed on the casing and the bolts split-pinned and wired together.

It is important that the worm wheel and differential assembly be fitted in the worm carrier the correct way round.

The heads of the differential bolts should be in the position so as to relieve the nuts of any direct loading.

Removal of Worm Shaft (Overhead type)

Draw off the coupling flange and remove the cover ; tapped holes are provided for jacking bolts. Draw the shaft through with the thrust bearing housing by screwing jacking bolts into the tapped holes provided in the housing flange ; the journal-bearing housing will be left in position. It should be noted on six-wheeled machines that the thrust race is at the front end of the worm shaft on the centre axle and at the rear end on the rearmost axle.

Removal of Worm Wheel (Underslung Worm Axle)

Remove bearing caps and lift differential assembly clear with its bearings. The outer races, cups, and adjusting nuts can then be removed.

To remove the worm wheel take out all the bolts, and if no press is available drive out the serrated half of the differential casing, using a brass drift about 2-in. diameter through the other half-case. The second half-case can then be driven out. If the case is tight, immerse the assembly in boiling water for fifteen minutes and then drive out the half-cases.

Alternatively, the worm wheel can be sawn through and the half-cases driven out. If this is done the bearings should be protected from swarf if they are to be used again.

Three $\frac{5}{16}$-in. holes are drilled through the half-cases to facilitate knocking off the bearings when renewing.

Fig. 1.—ANOTHER ARRANGEMENT OF OVERHEAD WORM REAR AXLE

A, shims for end-wise adjustment. *B* and *C*, bearings. *D*, bearing cups. *E*, cups. *F*, adjusting nut. *G*, set screws.

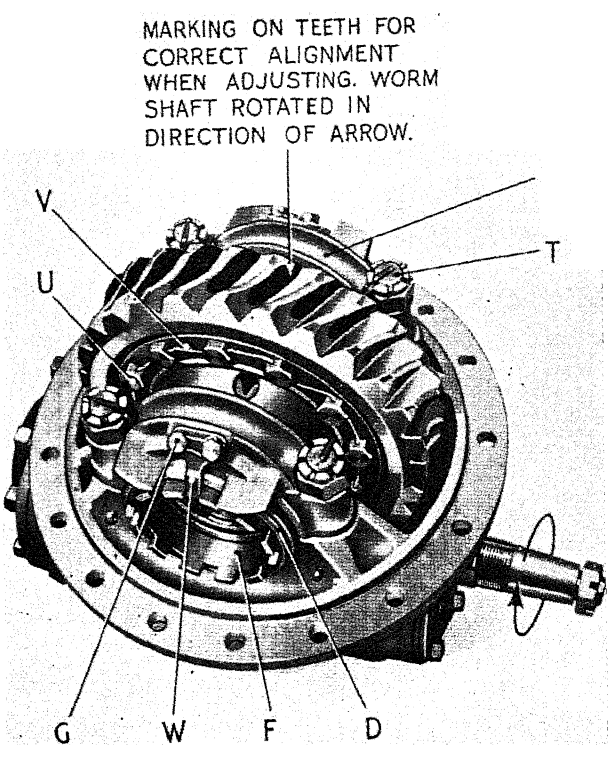


Fig. 8.—ALIGNMENT OF WORM AND WHEEL (OVERHEAD TYPE)
T, nuts. *E*, caps. *D*, cups. *F*, adjusting nuts. *W*, locking plates.

Replacing Worm Wheel (Underslung Worm Axle)

Renew the wearing pads (16), Fig. 5, behind the differential pinions if worn, and also the side-pinion bushes; the bushes are an easy fit on the pinions. If new roller bearings are to be fitted, replace the worm wheel on the casing before fitting the new bearings.

Immerse the worm wheel, flanged side down in boiling water, supporting it so that a hook can be slipped underneath to lift it out. Keep the water at boiling point for fifteen minutes.

Bolt the differential-case assembly solid by means of a long bolt through the centre and two pieces of flat steel or large washers. Clean any burrs off the fitting surface with a smooth file and remove any dirt with a wire brush. Smear the serrations liberally with oil.

If boiling water has been used to remove the worm wheel, allow the differential cases to cool off fully before fitting the new wheel.

Lift the worm wheel from the boiling water by means of a hook and support it on three wood blocks high enough to allow the differential assembly to go right home. Wipe the inside of the wheel clean and quickly insert the assembly, *taking care that the bolt holes correspond.* The wheel and casing are worked to facilitate registering the holes. Push the assembly down as far as possible and drive home, using a brass drift round the periphery, taking care to drive in evenly all round and that the assembly goes right home on the spigot.

Replace and tighten the bolts, remove the temporary fixing, wire the bolt ends and heads together.

If the roller bearings have not been removed, wash carefully with paraffin to remove all dirt and filings. If new ones are to be fitted, press or drive them on to the casing.

Removal of Third Differential (Six-wheelers)

On six-wheelers the third differential must be removed before the worm shaft of the centre axle can be withdrawn. This unit is housed in a casing secured to the front of the worm carrier. The worm shaft (25), Fig. 6, is hollow and the drive is transmitted to the third axle by a shaft (26) which passes through the hollow worm shaft. Renew the ring (7) and flanged bush (12) if the pinions are slack. The bush is an easy fit on the casing.

Removal of Worm Shaft (Underslung Worm Axle)

Draw off the front coupling flange, remove the gland housing (33), Fig. 5, remove the third differential on centre axles of six-wheelers. Take off the rear cover (19), screw jacking bolts into the tapped holes in the bearing housing (39), and draw out the worm shaft with the rear bearings. Two slots are provided in the shoulder on the worm shaft to enable the rear bearing to be driven off with a small bar.

Worm-shaft Gland

Oil loss along the worm shaft is prevented by means of a packless gland fitted on the front end of the worm shaft. On six-wheeled machines similar glands are fitted at both ends of the worm shaft on the centre axle.

The gland consists of a thin copper bellows, soldered to the cover, and having a bronze seating ring at the inner end. The necessary pressure against the seating washer is supplied by the spring. The gland requires no adjustment ; if after a long period of service oil leakage is apparent, a complete new gland should be fitted and the old one returned to Leyland Service Department for reconditioning.

Alignment of Worm and Wheel (after Overhaul or Renewal)

When reassembling after overhaul a double adjustment is necessary for alignment of worm and wheel and adjustment of differential side-bearings.

Clean all trace of oil from the worm carrier, fit the worm shaft, and adjust for end play. Coat the worm with a thin layer of marking blue and place the differential in position ; tighten the nuts so that the caps barely nip the cups on the outer races. Take all end play out of the side bearings by screwing up the adjusting nuts on both sides ; then adjust the right- and left-hand nuts, thus moving the worm wheel sideways until the correct alignment is obtained.

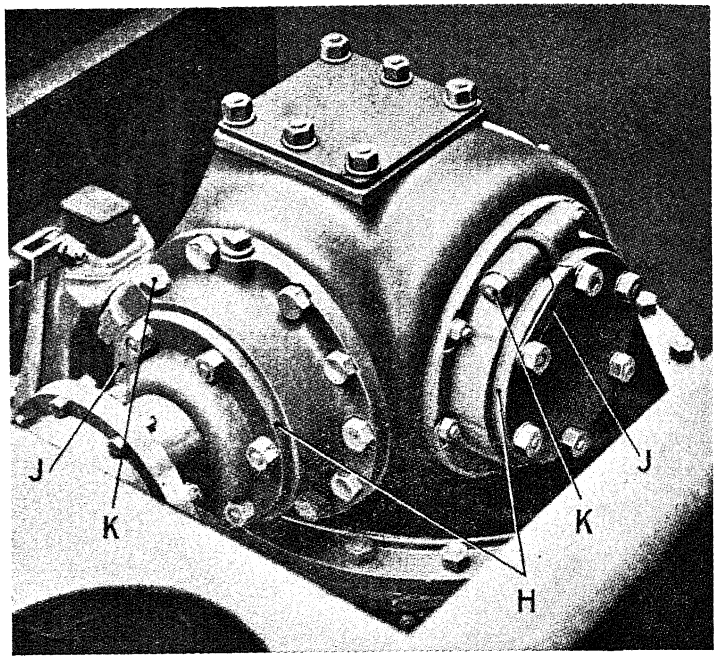


Fig. 9.—ADJUSTMENT OF BEVELS, DOUBLE-REDUCTION TYPE AXLES

Having obtained a tight adjustment by screwing up both nuts, slacken off each nut one notch and rotate the worm shaft in the direction of the arrow in Fig. 8, keeping a load on the worm wheel so as to obtain a good marking.

Fig. 8 shows the appearance of the wheel when in correct alignment. When rotating the worm shaft, the driving face of the tooth should show a marking of from one-half to three-quarters the width of the tooth on the leaving side. The entering side should not show marking ; when under load the contact will pull into centre.

If the wheel is loaded in a direction corresponding to " coasting," the contact marking will show on the opposite face of the tooth on the opposite hand.

When the alignment is correct, check for end adjustment, tighten and pin the nuts, and fix the locking plates (*W*). The setscrews should be wired together.

Replacing Worm Carrier

Before lowering the worm gear into the axle casing check that the leather oil seals on the axle shafts are in good condition. These are

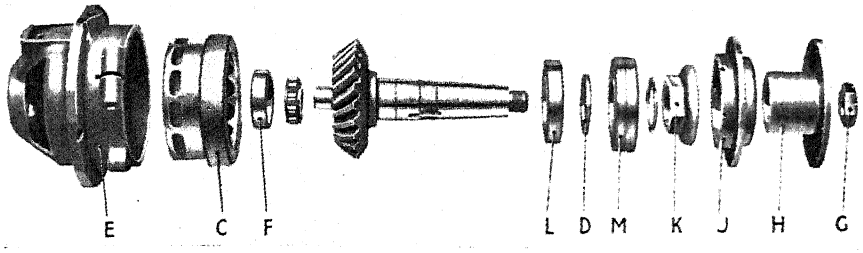


Fig. 10.—REMOVAL OF BEVEL-PINION SHAFT

mounted in aluminium sleeves located in the axle casing by dowel screws. The sleeves are a light tapping fit and can be withdrawn after removing the dowel screws.

When replacing the worm carrier see that the paper joint on the flange is not broken and check that the coupling flange is well home on the taper end of the worm shaft. See that the hub caps are tightened up.

Double-reduction-type Axles

Another rear axle is the fully floating double-reduction type, the first and second reductions being through spiral bevel gears and a double helical gear set respectively. Both bevel pinion and gear are adjustable for correct mesh, the double helical gear having sufficient end float to adjust itself to the pinion.

All pinions and gears are mounted in roller bearings, and large thrust-races are provided on the pinion shafts. The wheel hubs are mounted on taper roller bearings and need not be disturbed when removing brake drums and shoes.

Adjustment of Bevel Pinion and Gear

The double adjustment provided by the two adjusting rings (*H*), Fig. 9, permits of accurate meshing of the bevels to obtain quiet running. The bevel gear is moved laterally in the housing, and the pinion fore and aft, as the adjusting rings are screwed in or out.

Some backlash must be allowed, approximately ·005 in., otherwise the axle will be noisy under load and tooth wear will be rapid. If too much backlash is allowed the axle will probably be noisy on the overrun.

To adjust the bevels, remove the locking plates (*J*), Fig. 9, slack off the clamp-bolts (*K*), and turn the adjusting rings by inserting a small tommy-bar between the nuts securing the cover plates. Turn right for deeper mesh on the pinion shaft, left for deeper mesh in the case of the bevel gear. The bevels should be adjusted to have approximately ·005-in. backlash, and the vehicle then tried on the road for quiet running, until the most satisfactory adjustment is found.

When the adjustment is completed replace the locking plates and tighten the clamp-bolts.

Removal of Double-reduction Gear

Draw the axle shafts as already outlined and disconnect the Spicer coupling at the flange. Take off nuts from studs, and on six-wheelers disconnect the radius rod from the axle. The reduction gear can now be lifted out of the axle casing by means of a sling.

Removal of Differential Assembly

The double helical gear is spigoted on the differential casing and secured by alloy-steel bolts fitted in reamed holes ; the assembly is carried on roller bearings secured by caps (*A*), Fig. 11.

To remove the assembly unscrew the four nuts and remove the caps (*A*), when the assembly can be lifted clear. Remove the bolts, and the gear can be drawn off the spigot on the differential casing. The two halves of the differential casing can then be taken apart and the pinions inspected.

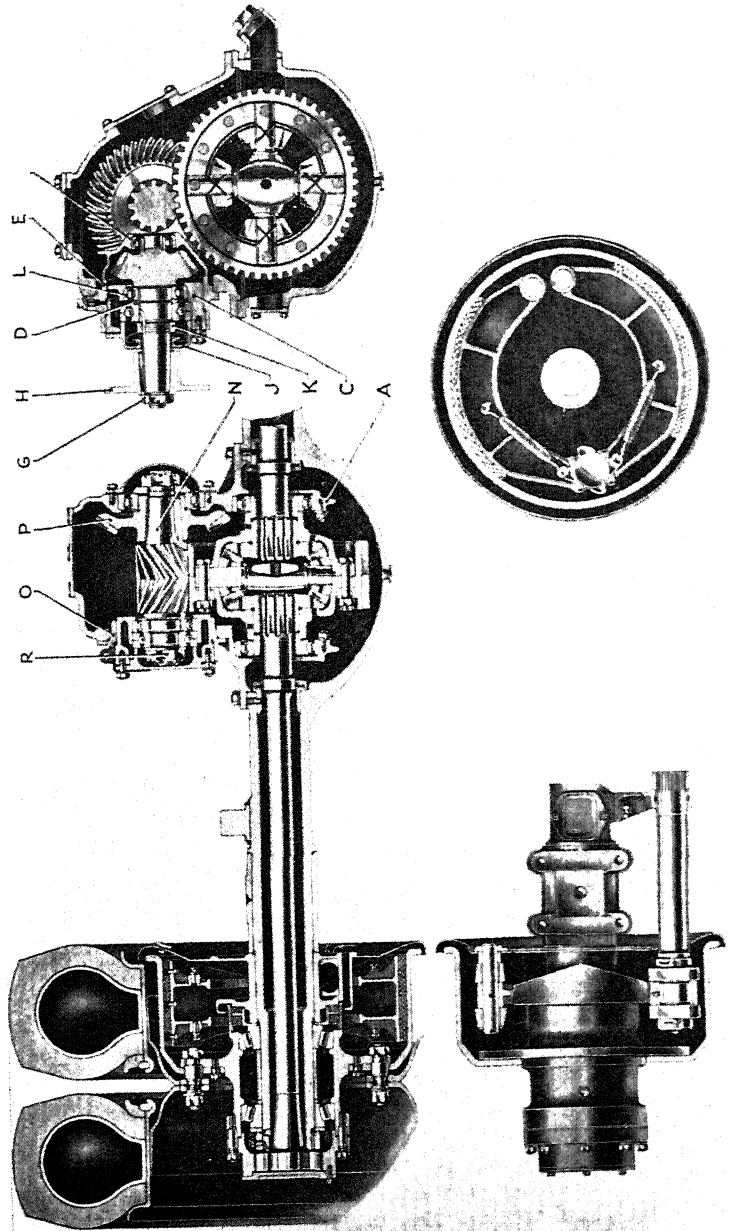
When reassembling see that the index marks on the differential side-cases coincide and that the contact faces are free from foreign matter which could prevent a perfect joint. The double helical gear should also be quite clean to ensure a good contact when pulled up on the spigot. The nuts must be tightened solid and split-pinned ; do not slack off a nut to insert a split-pin.

Removal of Bevel-pinion Shaft

The bevel-pinion shaft is carried in a roller bearing and a large thrust-race housed in an adjusting ring (*C*), Figs. 10 and 11. The bearings are locked on the shaft by a nut and tab washer, an oil flinger being secured to the nut by dowel screws. The adjusting ring is designed to ensure an adequate supply of oil to the bearings, a distance-washer (*D*) being fitted between the inner races of the bearings further to allow of efficient lubrication. The roller bearing is of the single-lipped type, and care must be taken when reassembling to ensure that the lipped side of the race is at the bottom.

The adjusting ring screws into the bevel-shaft housing (*E*), the shaft being supported beyond the pinion in a roller bearing, the outer race of which is a press-fit in the housing. The adjusting ring is secured by a clamp-bolt in a split-lug on the housing. A locking plate is provided, and a felt pad in the slot prevents oil leakage. The Spicer coupling companion flange is keyed on the taper end of the shaft.

To remove the shaft, unscrew the setscrews securing the shaft housing to the main housing and the assembly can be drawn out. Slack off the clamp-bolt, remove the locking plate and unscrew the adjusting ring (*C*), Fig. 10, the shaft will be drawn clear of the housing, leaving the outer race of bearing (*F*) in the housing. Remove the nut (*G*) and draw off the


E
L
D
H
G
N
J
K
C
A
P
O
R

Spicer flange (*H*), take off the cover plate (*J*) and unscrew the nut (*K*). Support the adjusting ring on the bench and give a sharp tap on the end of the shaft with a lead hammer, and the shaft can be drawn through the bearings.

When reassembling, fit the outer race of the roller bearing (*L*) in the adjusting ring with the lip downwards, and place the adjusting ring over the shaft. Fit the inner part of the roller bearing (*L*) on the shaft, then the distance-washer (*D*) and thrust-race; tighten the locking nut solid and lock with the tab washer. It is essential that the split outer race of the thrust bearing (*M*) be seated correctly before tightening down the cover plate. The Spicer flange must be a perfect fit on the taper, and the nut hammered tight.

Removal of Double-helical-pinion Shaft

The double-helical-pinion shaft (*N*), Fig. 11, is carried in a roller bearing and thrust-race housed in an adjusting ring. No distance-washer between the bearings is fitted in this case, and the roller bearing is not lipped. The adjusting ring screws into a special housing (*O*) bolted to the gear housing, and is secured by a locking plate and clamp-bolt. The bevel gear (*P*) is keyed on the taper end of the shaft and on it is mounted a roller bearing. Both bearing and gear are secured by a nut and split-pinned, the outer race being locked by the cover plate. To remove the shaft take off the cover from the adjusting ring, wedge the gear with a small bar of soft metal, and take off the locking nut (*R*). Slack off the clamp-bolt and place a small bar between the gear and housing so that when the adjusting ring is screwed out it will draw the thrust-race off the shaft. The shaft can then be withdrawn through the rear end of the gear housing.

The gear can be released from the taper by unscrewing the locking nut, supporting the gear on two blocks of wood, and giving a sharp blow on the end of the shaft with a lead hammer, or using a suitable drawer.

When replacing see that the gear is a perfect fit on the taper and that the nut is hammered tight and split-pinned.

Reassembling Reduction Gear

Fit the double-helical-pinion shaft in the offside roller bearing, and place the adjusting ring and housing in position. Tap the bearings on the shaft and tighten the locking nut solid.

It is essential that the split outer race of the thrust bearing be properly bedded before tightening down the cover plate.

Next fit the bevel-pinion assembly and finally the differential assembly. The bevels should be adjusted by means of the adjusting rings until there is approximately ·005-in. backlash. The mesh of the bevel pinion and gear can be checked by smearing the teeth of the pinion with marking blue and turning the pinion shaft in the normal running direction.

The marking should show about the middle of the gear teeth and along the whole of the width. The clamp-bolts should be tightened when the correct adjustment is obtained.

Before replacing the reduction gear in the axle casing check that the leather oil seals on the axle shafts are in good condition. These are mounted in aluminium sleeves located in the axle casing by dowel screws under the housing flange. The sleeves are a light tapping fit and can be withdrawn after removing the dowel screws.

Tab Washers, Split-Pins, and Chip Guards

It is important that the nuts indicated as being locked by tab washers or split-pins should have these safeguards fitted when reassembling; should the tabs break off on removal, new washers should be obtained and split-pins should be a good fit in the holes.

It is also essential that all chip guards should be replaced in their correct positions behind the bearings.

Ensure that all joints are in good condition to prevent oil leakage, and tighten the nuts round the housing flange after 2,000 miles' running.

Running Adjustment of Bevel Pinion and Gear

The most satisfactory method of obtaining the quietest adjustment of the bevel gear after overhaul or renewal is by running the vehicle on the road. Slack off the clamp-bolts and turn the adjusting rings until the quiet-running position is found; very little movement of the rings should be necessary. Fit the locking plates and felt pads and tighten the clamp-bolts hard when adjustment is completed.

Removal of Axle

The chassis should be well packed up both behind and in front of the axle to avoid excessive overhang.

On four-wheel machines disconnect the propeller shaft at the rear Spicer flange and sling the shaft to the cross-member. Disconnect the brake-operating rods, jack up the axle, and remove the road wheels.

Remove the shackle bolts and the axle can be lowered to the ground and removed.

On six-wheel machines first disconnect the propeller shaft and release the brake rods and radius rod from the axle. Jack up the axle and remove the road wheels. Next, lower the jacks slowly, whilst steadying the axle with a rope or sling, and allow the axle to turn over on the shackle pins until the top part rests safely on the ground. Finally, jack up a little to ease the shackle pins; withdraw these pins and lower the axle for removal.

Do not skid the axle on the brake dust covers; these should be kept clear of the ground.

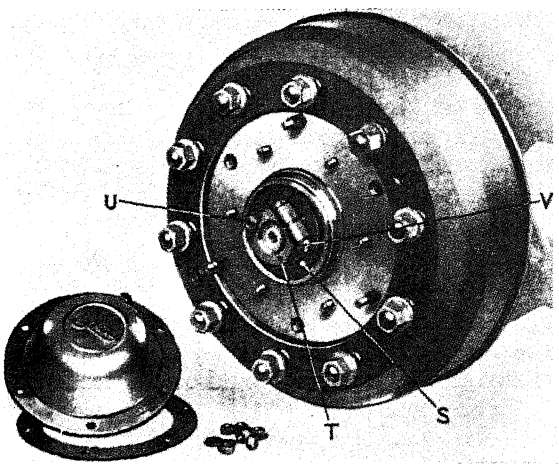


Fig. 12.—ADJUSTMENT OF HUB BEARINGS (BEAVER, OCTOPUS, AND TITAN)

BEAVER, OCTOPUS, AND TITAN FRONT AXLES

All Leyland front-axle beams are high-carbon nickel-steel heat-treated forgings. The axle arms are of nickel steel.

Adjustment of Hubs

The hubs are carried on roller bearings (*H*), Figs. 13 and 15, and these should be kept so adjusted that they have the minimum of rock or end play compatible with free rotation of the hubs.

To adjust the bearings remove the hub cap as shown in Fig. 12. The locking plate (*S*) is prevented from rotating by a flat which locates on a companion flat on the stub axle. The split-nut (*T*) has a lug into which is screwed a locking peg (*U*), the end of which fits in the appropriate one of a number of holes provided in the locking plate (*S*). The split-nut is clamped by a bolt (*V*).

Slack off the clamp-bolt (*V*) and remove the peg (*U*), screw up the nut (*T*) until there is no rock in the bearings. Then slacken back the nut one hole and replace the peg (*U*). Tighten the clamp-bolt, taking care that the nut is split-pinned before replacing the hub cap.

Removal of Hubs

Take off the hub cap, unscrew the peg (*U*), slack off the clamp-bolt (*V*), and screw off the nut (*T*). The hub can now be drawn off, bringing with it the outer roller bearing. When replacing, the hub must be packed with grease and carefully adjusted as already outlined.

Removal of King-pin

The king-pin (*J*), Figs. 13 and 15, fits in a taper in the axle beam, and is secured by a nut (*K*) pulled up on a distance-collar (*L*) and locked by a tab washer. Loss of lubricant is prevented by a felt washer (*M*) in a metal casing at the top and the cover plate (*N*) at the lower end.

To remove the king-pin in the case of Beaver and Octopus chassis (Fig. 13), take off the four nuts securing the servo to the platform, swing the servo carefully out of the way (take care not to strain the brake-operating linkage), and take off the cover plate (*N*). Slack off the nut

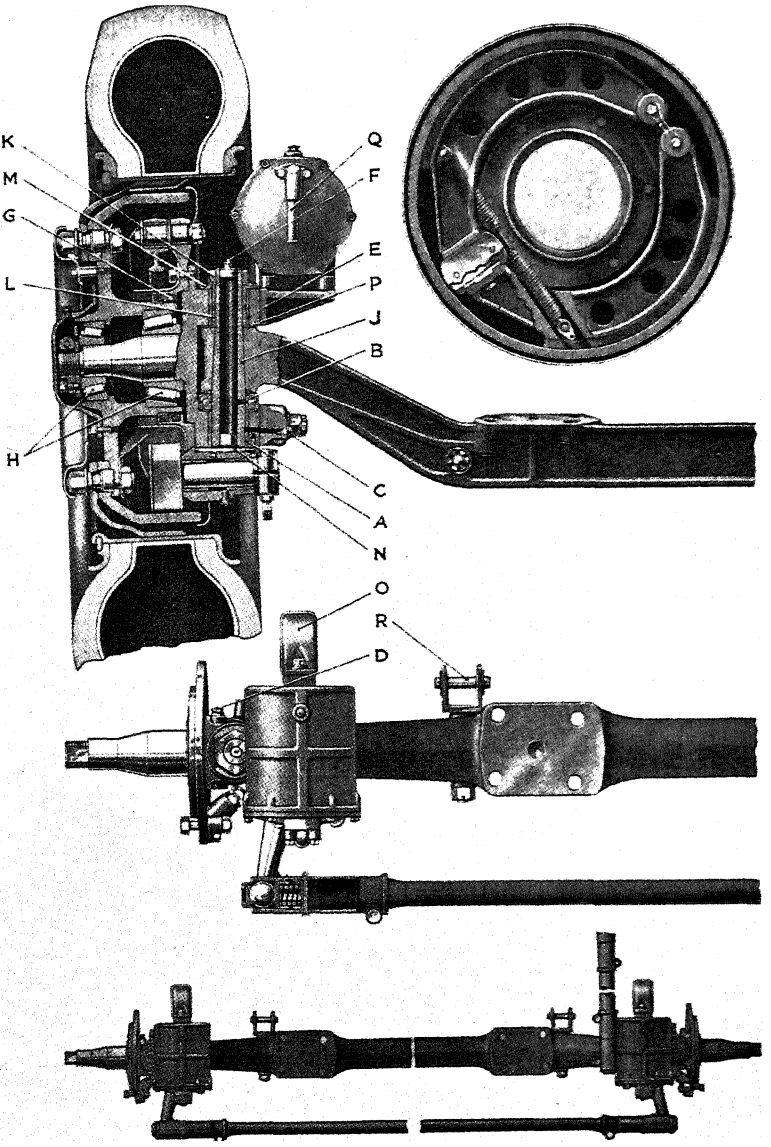


Fig. 13.—ARRANGEMENT OF FRONT AXLE (BEAVER AND OCTOPUS)

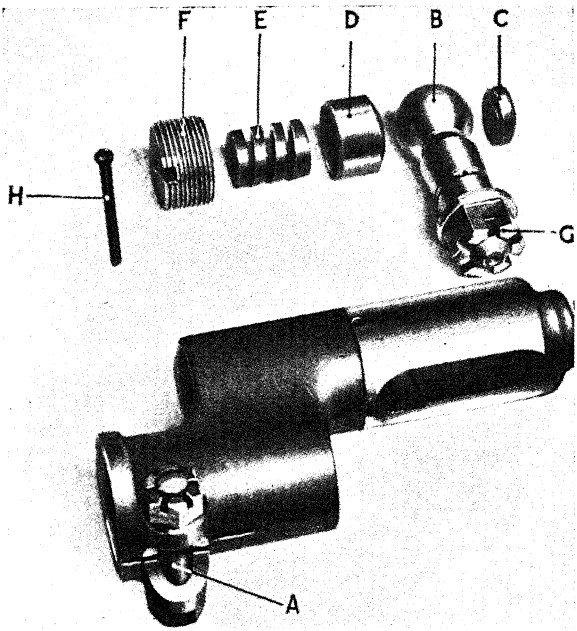


Fig. 14.—TRACK-ROD END

(*K*) one or two turns and release the king-pin, using a heavy lead hammer or a lead drift. Once the pin is released from the taper the nut can be removed and the pin will slip through.

To remove the king-pin on the Titan front axle, disconnect the brake-fluid pipe at the union (*O*) and remove the expander. Slack off the clamp-bolt (*P*) and remove the brake-camshaft lever, first marking the relative positions so that the lever can be replaced on the correct spline. Remove the nut (*Q*) and take off the cover; remove the lower cover plate (*N*). Slack off the nut (*K*) one or two turns and release the king-pin by striking the top end, using a heavy lead hammer or a lead drift. Once the pin is released from the taper the nut can be removed and the pin will slip through.

When replacing the king-pin on the Beaver, Octopus, and Titan chassis, see that the spherical seat for the thrust race is in position, and check that there is no undue clearance between the axle arm and the axle beam. The axle arm should be free, *without any up and down play*, and shim washers are available in six thicknesses for taking up such play. The washer used should be of such thickness that it is a push-fit between the axle arm and axle beam at (*P*) (Fig. 13) or (*R*) (Fig. 15). Before fitting the thrust-race it should be thoroughly washed in paraffin, dried, and packed with grease and enclosed in the mudproof casing. Never use a thrust-race that shows signs of wear or pitting. Tighten up the nut (*K*) hard, and lock with the tab washer.

Steering and Track-rod Connections

The steering and track-rod ends are one-piece forgings screwed to the rods for adjustment and clamped by a nickel-steel bolt (*A*), Fig. 14. The clamp-bolt should be inspected frequently for tightness; if a replacement is necessary, an ordinary mild-steel bolt must not be used.

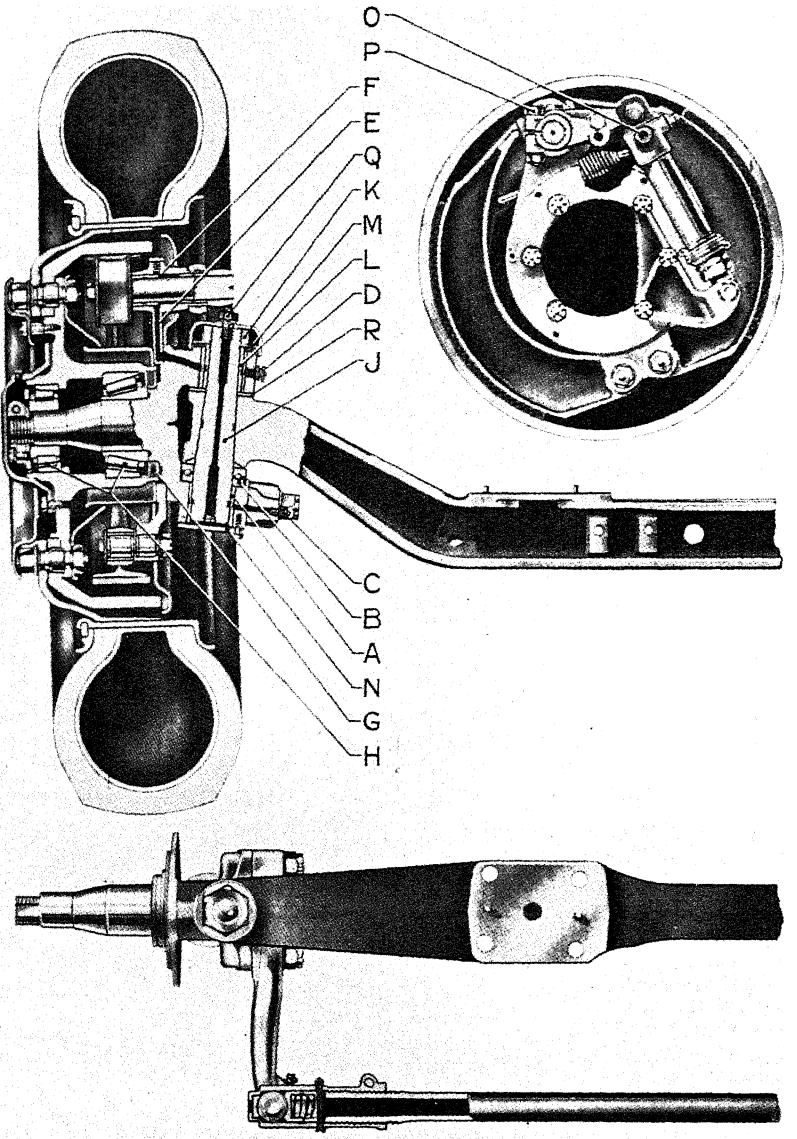


Fig. 15.—ARRANGEMENT OF FRONT AXLE (TITAN)

Serious damage to the adjusting thread will result if the bolts are allowed to remain loose.

The ball (*B*) is carried between cups (*C*) and (*D*), and a heavy, square-section coil spring (*E*) is inserted between the cup (*D*) and the spring housing (*F*). The rod cannot come adrift in the event of the spring breaking, as the slot in the steering-rod end is less than the diameter of the ball.

Removal of Ball End

Take off the nut (*G*) and release the ball-pin from the taper in the steering arm ; slack off the clamp-bolt (*A*) and unscrew the steering-rod end. Take out the cotter pin (*H*), unscrew the spring housing (*F*), and withdraw the spring and ball cup (*D*). The ball-pin (*B*) can now be removed through the end of the socket.

When replacing, clean and grease thoroughly and observe that the oil hole in the ball-pin is clear. Screw up the spring housing solid and then slack back half a turn, to ensure that the ball is not nipped. Be sure that the clamp-bolt (*A*) is well tightened and the nut split-pinned.

Track and Track Adjustment

The front wheels should be tracked up dead parallel. The ends of the track rod are screwed right- and left-hand threads to facilitate this adjustment.

Removal of Front Axle

Pack up under the frame side-members and disconnect the drag-link from the steering arm. In the case of Beaver and Octopus chassis, release the brake suction pipes at the hose clips at (*Q*), Figs. 13 and 15, and withdraw the shock-absorber connecting pins (*R*) when fitted. With Titan chassis, release the brake-fluid pipes at the unions. Remove the road-spring clips in all three types of chassis and the axle can be drawn clear. Do not drag the axle along the ground on the brake dust covers.

When replacing, ensure that the road-spring clips are dead tight ; these should be tightened with a long spanner and split-pinned.

LINX FRONT AXLE

Adjustment of Hub Bearings

On the Linx chassis the hubs are carried on taper roller bearings (*E*) Fig. 15, and these should be kept adjusted so that there is not more than ·005-in. end play.

To adjust the bearings remove the hub caps. The adjusting nut has six slots and the stub axle two holes at right angles, so that there are twelve positions for locking the hut with the split-pin. When reassembling or adjusting, screw up the nut until the bearings are just tight, then

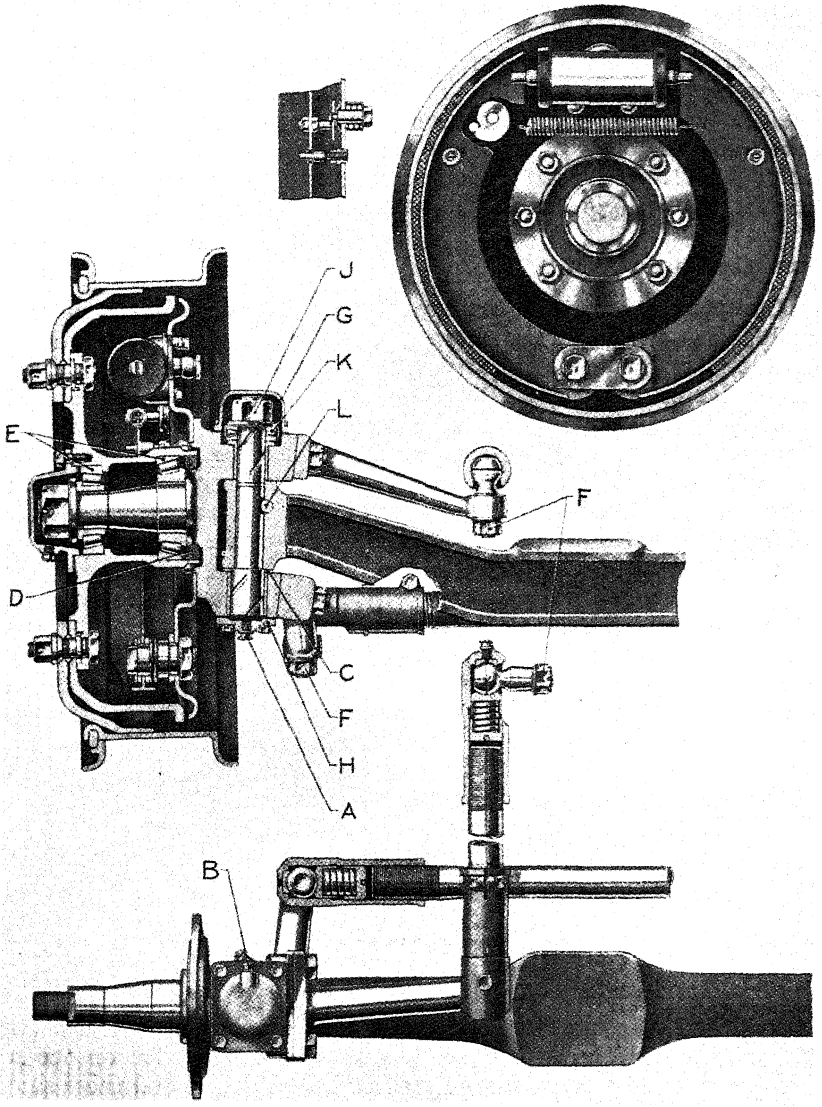


Fig. 16.—ARRANGEMENT OF FRONT AXLE (LINX)

slack back the nut till the nearest slot and hole are in line to insert the split-pin.

Removal of Hubs

To remove the hub take off the hub cap and unscrew the nut. The hub can then be drawn off, bringing with it the outer roller bearing.

If the bearings are to be renewed the outer races can be knocked out of the hub. Before pressing home the new races check that the recesses are free from foreign matter, which might prevent them going right home. Pack the hub with grease and adjust for end play as already outlined.

Removal of Axle Arm

Disconnect the steering connections by slacking off the nuts (*F*), Fig. 16, a few turns and drawing the pins through the steering arms. A drawer is available for this purpose ; a hammer should not be used, as there is danger of distorting the steering arms. Uncouple the flexible brake pipes ; the back plates and brake shoes need not be removed.

Take off the top and bottom covers (*G*) and (*H*), and unscrew the king-pin nut (*J*) ; the thrust-race (*K*) can then be removed. Remove the nut and drive the cotter (*L*) out towards the front, then drive out the king-pin by striking the top with a lead hammer to avoid damaging the threads.

If the bushes are worn, replace with new ones, a new king-pin being fitted if the new bushes are too slack on the old pins.

To reassemble, drive the king-pin in from below, care being taken to ensure that the slot for the cotter is in the correct position and that the felt washer (*C*) is replaced ; the cotter must be inserted from the front.

Fit the thrust-race, if in good condition, replace if at all pitted, and screw on the nut (*J*). This nut must on no account be tightened too hard—screw down tight and then slacken until the axle arm can just be rotated. Replace the covers and lubricate the bushes.

Similar remarks apply to steering arm and track-rod connections of the Linx as already given for the Beaver chassis.

BEAVER AND OCTOPUS BRAKES

Adjusting Hand-brake

On all four-wheelers the hand-brake is adjusted by means of a wing-nut ; on six- and eight-wheelers a turnbuckle is provided on the rear operating rod. Locking nuts are provided in all cases, and these should be tightened when adjustment is completed. The hand-brake should be adjusted whenever the foot-brake is taken up. Screw up the adjusting nut until tight, then slack back half a turn to ensure that the foot-brake can be fully released.

Adjusting Foot-brake

The foot-brake adjustment on four-wheelers is by means of the adjusting nut on the cross-shaft behind the servo. Screwing up the adjusting nut brings the servo reaction lever back against its stop, thus allowing full travel for the piston. With single-servo brakes the adjustment affects all four wheels; on other machines the rear wheels only are affected.

On six- and eight-wheelers two adjusting nuts are provided behind the servos on the cross-shaft. This adjustment is for the four rear wheels only.

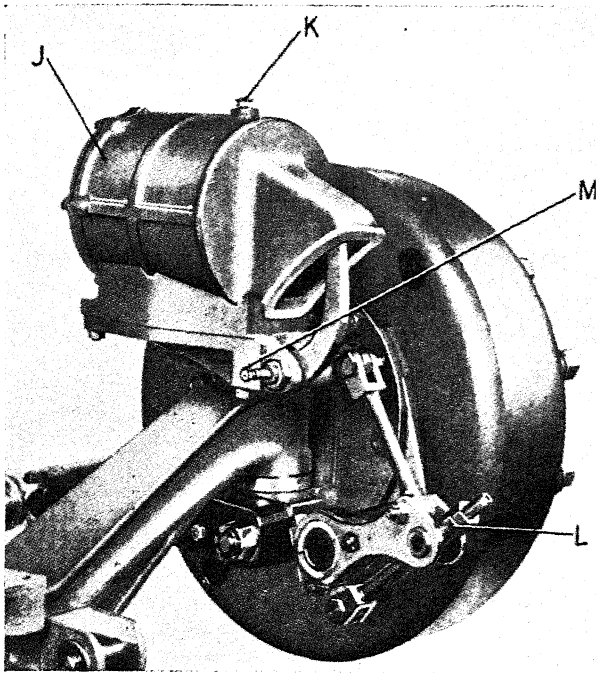


Fig. 17.—FRONT BRAKE ADJUSTMENT (BEAVER AND OCTOPUS)

Front Brakes

On all machines fitted with independent servos on the front axle, each front wheel must be adjusted separately. Jack up the axle, slack off the nuts locking the adjusting nuts (*L*), Fig. 17, and screw up the adjusting nuts until the shoes are just touching the drums, then release one half-turn and tighten the lock-nuts.

It should be noted that on all machines fitted with front-wheel servos, there is no mechanical connection between front and rear brakes. The front brakes should always be adjusted at the same time as the rear brakes.

In all cases it is most satisfactory to jack up when adjusting brakes, so that it is possible to test, by rotating the wheels, when the shoes are just touching the drums. The small amount of trouble is amply repaid by efficient braking.

Camshaft Levers

The $\frac{1}{2}$-in. thickness of the brake liners makes it desirable to reset the camshaft levers relative to the cams when the liners are half worn.

This is necessary to prevent the levers from pulling past the most effective position when applying the brakes, with a resulting loss in leverage and braking efficiency. With single-servo brakes the levers on all wheels require resetting; on all other models the rear wheels only.

Slack off the adjustment for hand- and foot-brakes and disconnect the ribbons or rods from the camshaft levers. Remove the clamp-bolt, mark both lever and camshaft, and slip the lever off the camshaft. Replace the lever with mark on the lever five serrations back from the mark on the camshaft, and tighten the clamp-bolt.

Couple up the ribbons or rods and adjust as outlined above.

Access to the front camshaft levers on single-servo machines is gained by removing the aluminium cover above the king-pin.

Overhaul

When the liners have worn down to $\frac{3}{32}$ in. it is time to reline. In most cases the brake shoes can be removed without disturbing the hubs.

TITAN BRAKES

The braking equipment on this machine is a combination of the vacuum-servo and Lockheed hydraulic systems. Adjusters are fitted in the brake shoes, which are mounted on eccentric fulcrum pins. The liners are $\frac{1}{16}$ in. thick. A half-turn should be given to the eccentric pins when the liners are half worn. A single pair of aluminium-alloy shoes is used on each wheel, the hand-brake being arranged to pick up the single cross-shaft and apply the rear brakes only.

The foot-brake pedal is connected to the servo by a ribbon and adjuster, the push-rod for the hydraulic master cylinder being connected to the reaction lever of the servo. The length of the ribbon should not be altered.

Shoe liners can be seen through inspection doors on brake back-plates. To adjust the fulcrum pins when the liners are half worn, on rear wheels take out the split-pins and remove the locking plate. With a spanner give a half-turn to each of the fulcrum pins. Replace the locking plate and split-pins.

On front wheels remove the split-pins and slotted nuts. Take off the locking plate, give the fulcrum pins a half-turn. Replace the locking plate, tighten and split-pin the nuts.

Adjustment of Brakes

Adjustment is effected by turning the worm shafts with a screwdriver. Jack up the wheels and turn the adjuster with a screwdriver in the slotted end of the worm shaft. The clearance between the liners and brake drum should be not less than ·015 in. The adjusters should be turned clockwise on offside wheels and anti-clockwise on nearside wheels to expand the shoes.

LINX BRAKES

The braking system on this vehicle embodies Girling wedge-operated self-centring shoes, hydraulically applied in the case of the foot-brake. In the case of the hand-brake, which operates only on rear wheels, application is by mechanical means, full compensation between the wheels being obtained by a swinging mounting secured on the rear axle.

Only one adjustment is provided, and that is direct on the brake shoes. A square-headed stud is provided on each backplate to adjust the shoes. Turn this stud with a spanner in a clockwise direction until resistance is felt, then slack back one notch, which can be both felt and heard. All adjusters operate in a clockwise direction. It is not necessary to jack up the wheels.

TITAN, BEAVER, AND OCTOPUS ROAD SPRINGS

Lubrication

Grease should not be used for lubrication purposes ; gear oil should be used in all cases, except for the rear-spring pivot bearings on six- and eight-wheelers, in which case engine oil should be used.

When docking, the vehicle should be jacked up under the frame, the springs cleaned and then painted with heavy oil, which will work into the springs in service.

Spring Shackles

An adjustment is provided for taking up play between the spring eye and the shackles or brackets. Excessive side play should not be allowed to develop at these points, and the adjustment should be carried out at every dock.

Slack off the clamp-bolts and remove the split-pins locking the adjusting nuts. Screw up the adjusting nuts until tight, then slack back one half-turn to give running clearance. The slots in the shackle pins are elongated to allow the necessary relative movement between the clamp-bolt and shackle pin. Play is taken up at the anchored end by a flanged bush. The spring eyes must not be nipped. Replace the split-pins and lock up the clamp-bolts ; the clamp-bolts must always be kept tight. Alternative split-pin holes are provided for locking the adjusting nuts.

On the rear springs of four-wheelers the shackle is mounted on a cross-tube. In this case, play at the pivot end of the shackle is taken up by releasing the tab washer and tightening the setscrew. The setscrew must be locked with the tab washer after making the adjustment.

Spring Bolts

The springs are secured to the axles or spring-seat brackets by alloy-steel U-bolts. It is essential that these are always kept dead tight ; inspect for tightness after the first 500 miles, and then at every dock.

The nuts are prevented from slacking back by shake-proof washers; the split-pins in the bolt ends are to avoid losing the nuts if they are slackened off. The only exception is on the rear springs of multi-wheelers, in which case the nuts are split-pinned.

The nuts may become slack due to slight stretch in the U-bolts or bedding down of the spring leaves. Loose spring-bolts will result in spring breakage and undue wear; brake judder can also arise from the same cause.

Inspect the springs periodically and replace any broken leaves.

On Titan chassis it is important that the U-clips securing the anchor plates to the spring are not tightened solid, as this will result in harsh riding. A clearance of at least ·015 in. must be allowed between the anchor plate and the top leaf of the spring when the vehicle is unladen.

If the rear spring has been removed from the spring-seat bracket of six- and eight-wheelers (Beaver and Octopus), it is essential that the U-bolt nuts are pulled up dead tight when replacing. The nuts should be tightened evenly, using a 4-ft. bar.

If a renewal is necessary, the needle bearings can be removed by taking off the wearing plates after removing the setscrews with the small key provided. The outer races can then be driven out of the spring-seat bracket.

When fitting new bearings, care must be taken that the needle rollers do not fall out. Tap the bearing well home into the recess, retaining the needle rollers by holding the inner race in position. Turn the seat bracket over and insert the distance-piece and the other bearing, then fit the wearing plate, tightening the screws evenly. Turn the assembly over and fit the other wearing plate. The assembly can now be handled without risk of losing the rollers.

Fit the inside thrust-washer and check that the felt washer is in its groove. See that the cross-tube is clean and smear it with oil. Support the spring with the front end on the ground and the bearings in line with the cross-tube. Ease the spring with a bar inserted through the bearings into the cross-tube until it can be pushed on to the cross-tube. The inner races and distance-piece are a push-fit on the cross-tube, and they must be lined up correctly and pushed on without using undue force. Light blows with a heavy block of wood will help.

Replace the outer felt washer in its groove, fit the thrust-washer, and tighten the ring nut hard. The spring should oscillate freely without end play. If play is excessive, fit new wearing plates or carefully grind the end of the distance-piece. If too tight, check that the bearings are driven well home in the recesses and that the wearing washers are tightened properly. Fit the locking plate, replace the setscrews, and give a good supply of engine oil through the nipple.

Replace the shackle pins, locking with the lock washers and clamp-bolts, and connect up the brake rods, propeller shaft, and radius rod.

Reassembling Springs

When reassembling springs after replacing a broken leaf, see that each leaf beds correctly at the tips and that the leaf clips are replaced. The replacement leaf should be obtained from a Leyland service depot.

At overhaul, springs should be dismantled and retempered. It is strongly recommended that broken springs and springs for retempering should be returned to a Leyland service depot, to ensure correct treatment and rebuilding.

Before replacing springs, make sure that the eyes are dead in line; the shackle pins should not be forced in. Except in the case of multi-wheeler rear springs, the springs should be mounted on the axle and the spring eyes checked for alignment; if they are out, the shackle pins cannot be replaced and the springs should be retempered and correctly set. The rear-spring U-bolts must be pulled up dead tight, using a 4-ft. bar. Tighten the nuts evenly, adjust all shackle pins, and tighten all clamp-bolts.

LINX ROAD SPRINGS

Grease must not be used for lubrication purposes; gear oil should be used in all cases.

An adjustment is provided for taking up end play on the shackle pins. This adjustment should be carried out when docking. To adjust the pins, slack off the clamp-bolt nearest to the slotted nut, remove the split-pin, and tighten the nut. Slack back one half-turn to give running clearance, replace the split-pin, and tighten the clamp-bolt.

Spring bolts are treated in the same way as described for Beaver vehicles.

THE MORGAN 4/4 CAR

THE following notes relate to the Morgan 4/4 cars from 1936 to 1939.

Transmission

The only parts of the Hardy Spicer universal joints subject to wear are the journal and roller-bearing assemblies. When for any reason it becomes necessary to replace them, there is no necessity to remove the shaft from the car.

Remove bolts from companion flange at gearbox end of shaft and unscrew sleeve-yoke assembly. Then to dismantle :

(1) Remove snap-rings by pinching ends together with a pair of pliers. If a ring does not readily snap out of the groove, remove enamel from the yoke holes and tap the end of the bearing lightly, which will relieve pressure against the ring.

(2) Holding the joint in one hand, tap gently with a piece of copper or copper hammer on the radius of the ear of the yoke. The needle bearing will gradually emerge and can finally be removed with the fingers. Be sure to hold the bearing in a vertical position, and when free remove race from bottom side so as to avoid dropping the needle rollers.

(3) Repeat this operation for the opposite bearing.

(4) Support the two exposed journal pegs on lead blocks (to protect ground surface) and tap the ears of the flange yoke to remove the race.

(5) Reverse assembly and repeat the operation.

(6) Wash all parts in petrol.

(7) If parts are not worn, repack with a good grade of semi-fluid lubricant (160 S.A.E.). Make sure that the journal oil channels are filled with lubricant. With the rollers in position fill the race about one-third full.

Should any difficulty be encountered when assembling rollers in housing, smear the wall of the race with Vaseline. It is advisable to install new gaskets and gasket retainers on the journal assembly. The journal shoulders should be shellacked prior to fitting retainers, so as to ensure a good oil seal. It is also useful to have snap-rings available as replacements in the event of damaging a ring in dissembling the joint.

To Reassemble

(1) Insert journal in flange-yoke holes.

(2) Using soft round drift with flat face about $\frac{1}{32}$ in. smaller diameter than the hole in the yoke, tap the bearing into position.

(3) Repeat this operation for the three other bearings.

(4) Replace snap-rings, and be sure that these are firmly located in the grooves.

When assembled, if joint appears to bind, tap the lugs lightly with a wooden mallet, which will relieve any pressure of the bearing on the end of the journal.

Do not use grease in Hardy Spicer needle-bearing joints, as it is liable to clog the oil passages.

Rear Axle

All adjustments that may be necessary from time to time can be made without removing the complete axle from the chassis.

Differential adjustments are made after removing the differential and pinion housing from the axle case. Hubs, hub-bearing cups, and axle shafts are first removed. Bevel-pinion adjustments call for removal of propeller-shaft flange, oil retainer, thrust cover, and extraction of bevel pinion with races in position. The method of adjustment is by pressing off the ball race and inserting shims if the pinion is to be adjusted "in," or removing shims to adjust "out." The crown-wheel is adjusted by inserting a square bar in the slots on the differential-bearing locknut, after slackening off differential cup bolts and turning back the locking tabs.

When setting crown-wheel and pinion, endeavour to obtain a marking about $\frac{3}{8}$ in. along the inner portion of the tooth. If possible, run the gears at about 1,000 r.p.m. with some raddle or surface blue on the teeth. Apply load by holding a stout stick against the crown-wheel.

When rewiring the differential cup bolts, make sure that the wire passes over the locking tabs to keep them in position.

Hub bearings can be adjusted by insertion or removal of shims between cups and brake anchor plates after taking off hubs and drums. Adjust until there is the smallest amount of play possible, allowing the shafts to turn freely.

Use a new joint washer when refitting differential assembly.

Brakes

Front brakes are arranged to come on slightly before the rear. There is no alteration for this setting. Adjusters are provided for taking up slack in cables, but no attempt should be made to take up more than stretch. Adjustment is made at adjusters on backplates. See (7) below.

Relining

(1) Jack up the car in the manner previously described and remove road wheels.

(2) Remove drums. The rear-wheel drum is secured by two countersunk screws; remove these screws and the drum can be tapped off, disclosing the brake shoes, etc. In the case of the front-wheel drum, it is

necessary to remove the complete hub, and this can be done only by the use of a suitable drawer.

(3) To dismantle the brake. All that is required is a large screwdriver. With this it will be found quite easy to prise one shoe out of the groove in the plunger at expander end. Both shoes and springs can now be removed, leaving expander and adjuster units in position on the backplate. Be careful not to overstretch the spring when removing shoes.

(4) Clean down the backplate and check expander and adjuster units for free working. Slacken back adjuster (anti-clockwise) to full "off" position. Adjuster cone spindle should screw quite easily into housing. Inspect shoe pull-off springs, and replace if stretched or damaged.

(5) Detach springs from old and refit to new shoes. Be sure that the springs are between shoe webs and backplate, otherwise shoes will not lie flat on plate. Keep all grease off brake linings. Place shoes with springs attached against backplate. Fit shoe ends to adjuster grooves. Shoes have half-round slots at one end; fit these slots to the adjuster plungers; then insert other end of shoe in expander plunger. Insert screwdriver under web of remaining shoe and ease into plunger groove.

(6) Refit drums. Be sure they are clean and free from grease, etc.

(7) To ensure correct clearance between shoes and drums, slacken off set-pins that hold adjuster to backplate one complete turn, and lock up brake shoes in the drum by turning the adjuster in a clockwise direction. Bolt up adjuster set-pins tightly and slacken off adjuster to nearest notch. Give the brake pedal a firm application, to ensure that the shoes have centralised. Drums should now be quite free.

(8) Refit road wheels and jack down. The operation of relining is now complete, nothing further being required.

Important

Do not tighten up the brass expander nuts on outside of backplate. Do not handle linings with greasy hands. Do not overstretch shoe pull-off springs when removing shoes. Do not remove expander and adjuster housings from backplate. Do not forget to tighten up firmly adjuster-housing set-pins. Do not fit any other than "Girling" replacement shoes, which are correctly riveted and ground to correct periphery, ensuring a fast and easy bed-in to drum.

Steering and Front Suspension

The front wheels are suspended independently on spiral springs, and slide vertically on the main axle pins that hold the complete assemblies in position. The sliding axles, wheel spindles, and brake plates form complete units and require no other attention than that of lubrication. Phosphor-bronze bushes are pressed into the sliding axles. New bushes become necessary with wear, but a period at which renewal should be made cannot definitely be laid down.

The method of dismantling is simple, and is carried out in the following manner :

Jack up front of car to a height of at least 15 in. and remove road wheels. Remove pins from track-rod ends (while out, clean off and wipe over with damp oily rag) ; uncouple shock absorbers (take this opportunity of replenishing liquid if required), slacken off and remove nuts over top end lugs of cross-axles. The vertical axle pins can then be drawn down and out, when assemblies with hubs complete can be removed. When reassembling see that all nuts are tight and properly cottered. Do not reassemble track-rod pins in oil ; excess lubricant negatives their damping properties. Check wheels for alignment. Errors in misalignment can be corrected by adjustment of the track rod, the ends of which are threaded for the purpose. Toe-in should not exceed $\frac{1}{8}$ in. Toe-out is to be avoided. Rear wheels should be parallel.

The steering column calls for no attention beyond occasionally removing the plug from oil filler and refilling with oil. The drop-arm connecting drag link to column fits on a spline. If at any time it is removed, care should be taken to see that it is again fitted to the correct serration. Adjustment which requires no explanation is provided at either end of the drag link when found to be required.

Bodywork

The body is held down on chassis by seven bolts each side. To remove, take out bolts, remove steering-column clip, remove pedal board, and disconnect wiring. To remove petrol tank from two-seater, the two rear bolts on each side of wooden frame underneath have to be taken out. This allows frame to hinge on front bolts and to drop sufficiently to allow neck of filler to clear panel.

Shock Absorbers

The filling of the shock absorbers is a comparatively simple matter, which is carried out in the following manner :

Remove the shock absorber from the brackets.

After drawing off dust cover, grip cylinder by square peg in a vice, unscrew the main gland, draw the piston out of cylinder, empty out old liquid, refill to within about $\frac{1}{2}$ in. of the top, replace gland, push up slightly, and carry out the test explained below to prove that there is the correct amount of liquid in the cylinder. After correct amount has been determined, tighten gland finally.

It is essential that a test should be carried out to ensure that the absorber is not overfilled, by holding the cylinder and gripping the square piston rod in a vice ; make sure that it will compress to its maximum amount. If there is too much liquid in the cylinder it will be possible only to compress the absorber to half or three-quarters of its full stroke,

in which case a little of the emulsion must be removed so that the absorber will just compress to its maximum.

On the contrary, should the absorber go to its full stroke and easily bottom, add a little more emulsion until the absorber will compress to within about $\frac{1}{4}$ in. from the end of the stroke. We may mention that it is not a particularly important factor if the absorber is a little short of liquid, but it is most essential that overfilling be avoided, as this results in the stroke being limited, and the springs will not be allowed to flex.

Rear Shock Absorbers

The André multiplex shock absorbers fitted to the rear are set to a certain initial tension before they leave the factory. No change in this adjustment should be made until the car has been driven about 100 miles on good and bad roads, and at no time should the shock absorbers be adjusted up dead tight.

Carefully note the riding qualities of the car. If the spring action seems too free, increase the friction resistance of each shock absorber by turning the centre adjusting nut to the right, or clockwise, by not more than one graduation at a time.

If the spring action seems too retarded and feels stiff, reduce the frictional resistance again by turning the adjusting nut to the left, or counter-clockwise. Careful adjustment in this manner will produce an ideal condition. The springs will still have the required amount of flexibility for easy riding, but spring vibration will be reduced to a minimum and violent rebound effectively eliminated.

Readjustment may become necessary only after several thousand miles of car travel, and should be made only when the spring movement seems too free, and then the indicator should be moved not more than one-half of a graduation at a time.

It should be noted that the full benefit of the shock absorbers will not be felt when the car is travelling at low speeds, as under these conditions the spring movement is very limited, but as the speed increases their effect becomes more pronounced, especially over bad roads, when the spring action is most severe. Testing and adjustment should, therefore, be carried out at comparatively high average touring speeds.

The frictional resistance required to effectively control the action of the springs is comparatively small, and care should be taken not to increase the pressure more than is absolutely necessary when adjusting to obtain the desired results. The initial factory setting of the shock absorbers is approximately correct under normal conditions, but for road and track racing a considerable increase in pressure may be required.

Rear Springs

If removed, examine Silentbloc anchorages and renew if worn. See that trunnions in rear chassis cross-member are refitted with solid half at top.

THE SCAMMELL MECHANICAL HORSE

THE Scammell Mechanical Horse is a five-wheeled articulated vehicle, consisting of a three-wheeled motive unit and a two-wheeled trailer superimposed at its forward end on the motive unit. The following notes relate to all models, unless otherwise stated.

STEERING AND FRONT WHEEL

The steering wheel rotates the vertically mounted front fork by means of spiral gearing which consists of a hardened steel worm and a phosphor-bronze worm wheel. Castor action is provided. The front fork and steering arms are steel stampings. The reduction ratio is approximately 12·5 to 1; on the earlier type it is 6 to 1.

Use "Shell" gear oil for lubricating the steering gear. Fill to top of filler orifice. The capacity is approximately 1 pint.

To Remove Steering

Remove the front mudguard grille, jack up the front of the motive unit, and remove front wheel.

The chassis must be lifted about 5 in. *after* removal of the two nuts which secure the hub spindle to the spring arms. By manœuvring the wheel it can be withdrawn complete with the hub. Under the arch of the forks will be found a slotted nut which secures the forks to the pivot pin; remove this nut and give the forks a sharp blow downwards to free them from the taper on the pivot. Remove the key from the pivot pin. Support the petrol tank and disconnect the tank brackets from the steering box. It is now necessary to split the steering box by removing the setscrews which connect the box to the pivot housing. Have a tray and some rag ready to catch the oil, and carefully raise the box assembly clear of the pivot-pin top. The bolts holding the pivot housing to the chassis can now be removed and the housing removed from the chassis.

When replacing the steering make sure that the forks are put up with the dampers to the front and the large springs to the rear, as there are two bosses at the top of the forks which act as stops in conjunction with two round-head bolts in the front cross-member.

On earlier models a plate was held in position under the pivot housing to act as a stop; this must be replaced in its correct position. When reassembling the steering head, ensure that the shims are replaced under the thrust-race cap to allow a free running fit of the pivot pin. If the steering is stiff or heavy, check the front-tyre pressure, which should be 50–55 lb.

Oil leaks from the bottom of the steering case on to the front tyre will usually be cured by lowering the oil level by $\frac{1}{8}$ in. or so. If this does not effect a cure, a new steering-pivot bush must be fitted.

To Remove Tyre from Rim

These instructions apply to all sizes of tyres fitted to the "mechanical horse" except 34 in. × 6 in., which is of the loose-flange and spring-ring type. The wheels are built up in two halves and joined together with bolts round the central flange. Always deflate the tyre before removal from the hub.

Remove the collar nuts from the wheel studs—offside right-hand thread, nearside left-hand thread—and remove the wheel from the hub. The rim is now split by removing the nuts on the bolts round the central flange. Care should be taken when reassembling the wheel to make sure that the valve groove in the one half coincides with the valve hole in the other half.

To Dismantle Front Hub

Remove the oil retainers and covers from each end of hub, drive out the spindle from either end. This will come out complete with one race; the other race is removed by means of a drift inserted through the hub.

Note ball races when reassembling. If the word "thrust" appears on the rings, it will denote that they are dual-purpose races and must accordingly be assembled and refitted with this marking on the *outside* of each end. Having assembled the hub, it should be checked to ensure that the spindle has from ·005 in. to ·010 in. end float. If new races are fitted, these must be from a "push" to a light tapping fit on the spindle.

Front Shock Absorbers

These should be adjusted by means of the nuts under the two spiral damper springs on each side of the hub. To replace the friction linings—remove the front and rear covers, take the weight of the unit on a jack under the front cross-member, and remove the side plates. After removing the drums, the plates to which the linings are attached can be dismantled. When reassembling, ensure that the grease ways are all clear, and thoroughly grease all parts prior to replacing.

Adjustment of Steering-column Races

If at any time it becomes necessary to take up end play in the steering column, proceed as follows: The nut which retains the steering wheel to the column has a screwed peg running through the centre of it, secured by a split-pin through the nuts. Remove this split-pin and unscrew the nut a few turns, slacken the $\frac{1}{2}$-in. bolt clamping the steering wheel to the column. Screw out the peg in the centre of the nut by a quarter-turn,

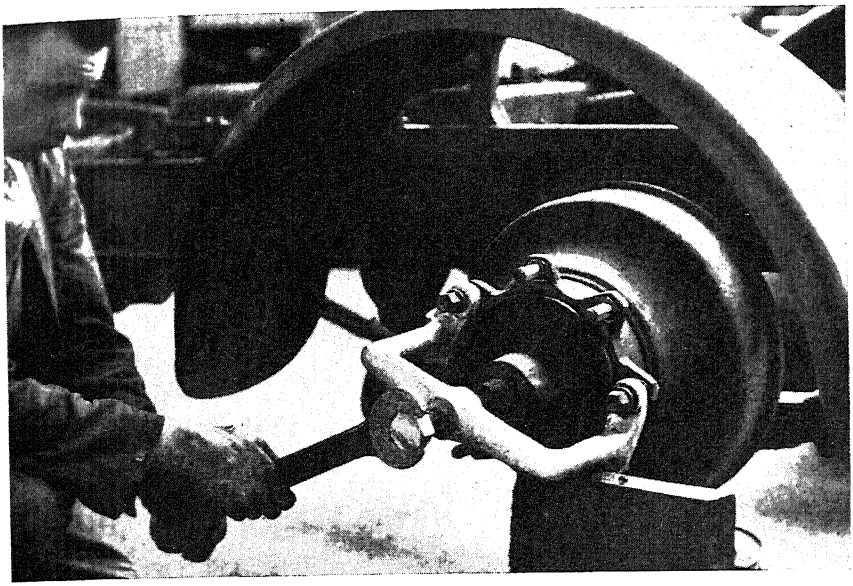


Fig. 1.—REMOVING DRIVING-WHEEL HUB WITH SPECIAL EXTRACTOR

and then tighten up nut and peg together. Give nut a sharp blow with a hammer or mallet to free the ball races.

If the end play is not completely removed, repeat the operation, giving a quarter-turn to the peg each time until all end play is taken up. Finally, split-pin the nut and peg and retighten the wheel-clamping bolt.

PROPELLER SHAFT

Hardy Spicer type propeller shafts are used, incorporating their K.R. type universal joints. The following size joints are used: M.H.3—1,250; M.H.6—1,300. The trunnions and needle-bearing assemblies are the only parts subject to wear, and should it become necessary to replace these at any time, the design is such that correct assembly is a very simple matter. No hand fitting or special tools are required.

To Dismantle

To dismantle, commence by removing the lock rings which hold the needle bearings in position. This is done by squeezing them together with a pair of pliers. To remove the needle-bearing assembly, first remove the burrs and paint around the edge of the hole, then tap the yoke sharply with a mallet at a point near the bearing, which will then drop out. Do this for each bearing; it will then be found possible to remove the journal.

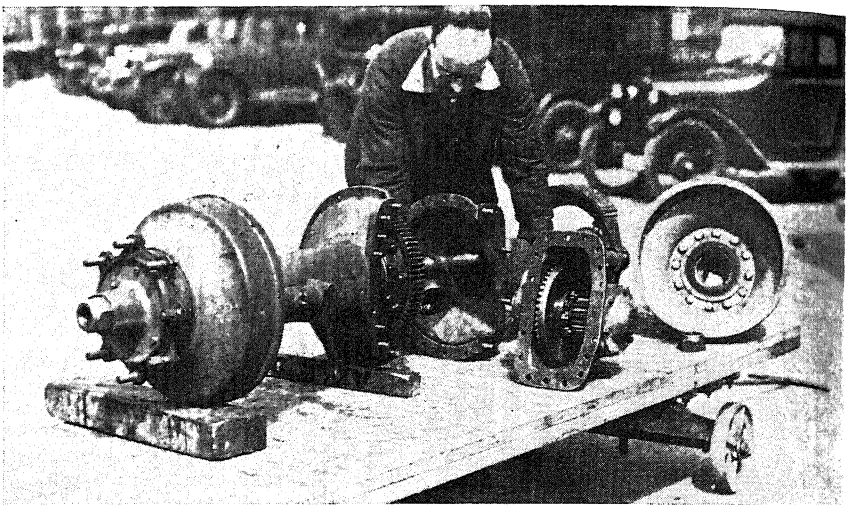


Fig. 2.—DISMANTLING DRIVING AXLE OF MECHANICAL HORSE

The distance-pieces on each side of the ball races must be marked to ensure their replacement on the same side on reassembling.

Reassembling

To facilitate reassembling the bearings, the needles should be lightly smeared with a thick oil or vaseline to hold them in the race. Hold the trunnion in vertical position and press the bearing into the yoke from the bottom ; this should prevent the needles from falling out.

If the clip joint is removed from the shaft, care must be taken to reassemble so that the sleeve-yoke lugs lie in the same plane as the stub ball-yoke lugs. Arrows are stamped on the sleeve and shaft for this purpose. Transmission vibration has been traced to incorrect assembly of these components.

It will be appreciated that, due to the low axle ratios necessary with this type of vehicle, the speed of the propeller shaft is much higher than on normal-type vehicles, so that to ensure trouble-free running, regular lubrication of the joints is necessary.

Lubrication

The trunnion cross on the later-type models (fitted to vehicles delivered after 1st August, 1937, approximately) is provided with a large interconnected oil reservoir in each end. These reservoirs are filled with lubricant at the time the joints are assembled, and should require replenishing only at intervals of 15,000 miles or when the vehicle is overhauled, whichever is the more frequent. To do this, one needle-bearing assembly should be dismantled, when by holding that journal upright the joint may be filled with lubricant.

In the case of the older types of propeller shafts (on vehicles delivered before 1st August, 1937, approximately), where the reservoirs are not inter-connected, the joints should be dismantled, cleaned, and replenished with oil every 6,000 miles. Messrs. Hardy, Spicer Ltd. recommend the use of 160 S.A.E. oil (Shell gear oil or Spirax heavy) for both types.

DRIVING AXLE

The driving axle is of the double-reduction type, incorporating four-pinion differential, high-tensile-steel alloy spiral bevel and spur gears. The axle shaft is of the three-quarter floating type, with stamped hubs run on ball bearings.

Alternative axle reduction ratios are available as under :

M.H.3

Approximate ratio of	9·25 : 1	M.H.6/3 motive unit
,, ,,	10·28 : 1	Standard 3-ton loads
,, ,,	12·33 : 1	Refuse collectors with special loads of 4 tons or in hilly districts
,, ,,	14·51 : 1	3/6-ton carrier (6-ton load)

M.H.6

Approximate ratio of	13·23 : 1	Standard 6-ton loads
,, ,,	17·11 : 1	Special loads up to 10 tons
,, ,,	19·44 : 1	10-ton loads in hilly districts
.. ..	22·51 : 1	Exceptional cases

Driving and braking torque is taken by semi-elliptic springs.

Lubrication

Use " Shell " Double Oil. Fill to top of filler at rear of axle, not by brass inspection plug.

Removal of Axle from Chassis

Disconnect brake rods and rear end of propeller shaft ; jack up rear of chassis frame in front of axle under both side members. Remove wings, shackle pins, and shackle bolts. The axle can then be wheeled out from under chassis.

Dismantling Driving Axle

Detach front gear casing from main-axle casing, take off axle-shaft nuts, and withdraw hubs by means of a special extractor. Remove keys from tapered ends of shafts. Remove bolts from axle casing and lightly tap casing apart. Care must be taken to note the distance-pieces which are fitted either side of ball races ; these must be correctly replaced when reassembling.

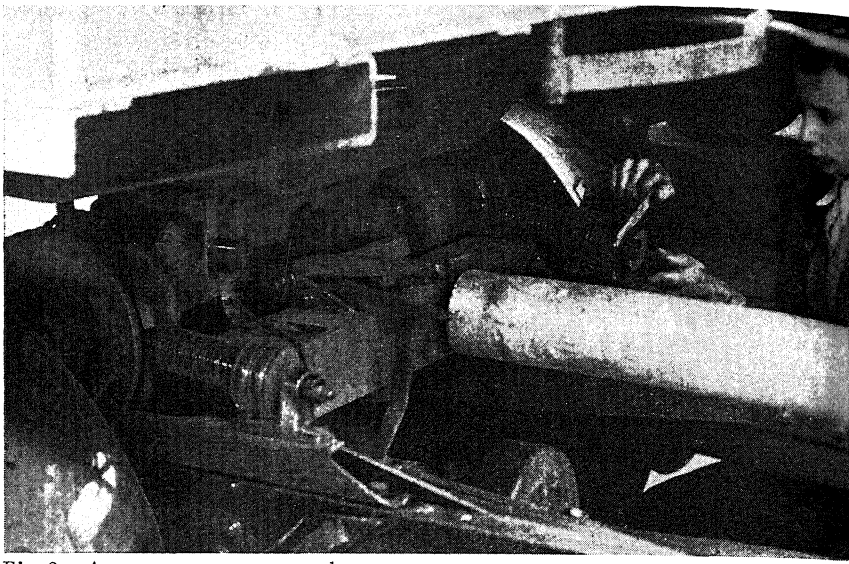


Fig. 3.—ADJUSTING BUFFERS TO $\frac{1}{8}$-IN. CLEARANCE BETWEEN NUT AND BUFFER BRACKET WITH UNIT COUPLED TO CARRIER

To Remove Large Spur Wheel

Take out bolts and lightly tap off wheel which is spigoted on to the cage. Take away bolts which hold two halves of cage together, then remove differential spider and pinions. The axle shaft with bevel can now be drawn out from the cage.

To Dismantle Front Gear Casing

Take off spur-pinion caps, the offside one of which may incorporate the mileometer or speedometer drive, and the nearside one the speed pilot. Note carefully the number of shims fitted to each cap, for re-assembling purposes. Remove the nuts from the spur-pinion shaft, drive out shaft by striking from the *nearside*; it will then come through complete with the offside ball race. Remove the nearside ball race by means of a drift inserted through casing. The bevel wheel and spur pinion can now be removed.

M.H.3

To remove bevel pinion, take out setscrews holding transmission brake drum in position, then remove brake-shoe fulcrum pins. The fulcrum bracket should be dismounted by removing the setscrews which hold it to the gearcase. Disconnect wire and take out ball-race locking screws from nearside of gear casing. The bevel pinion can then be tapped out, complete with ball races.

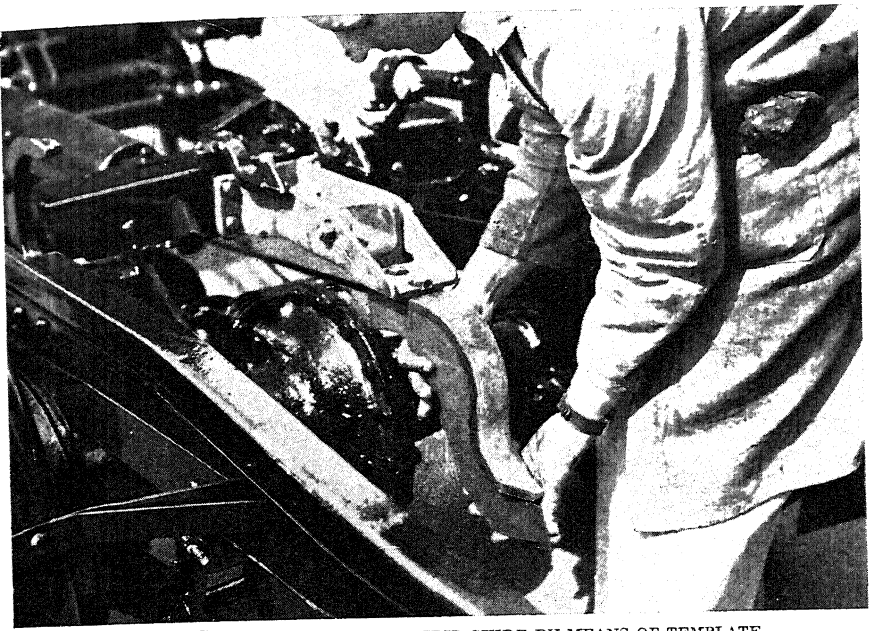


Fig. 4.—CHECKING CONTOUR OF TRIP GUIDE BY MEANS OF TEMPLATE

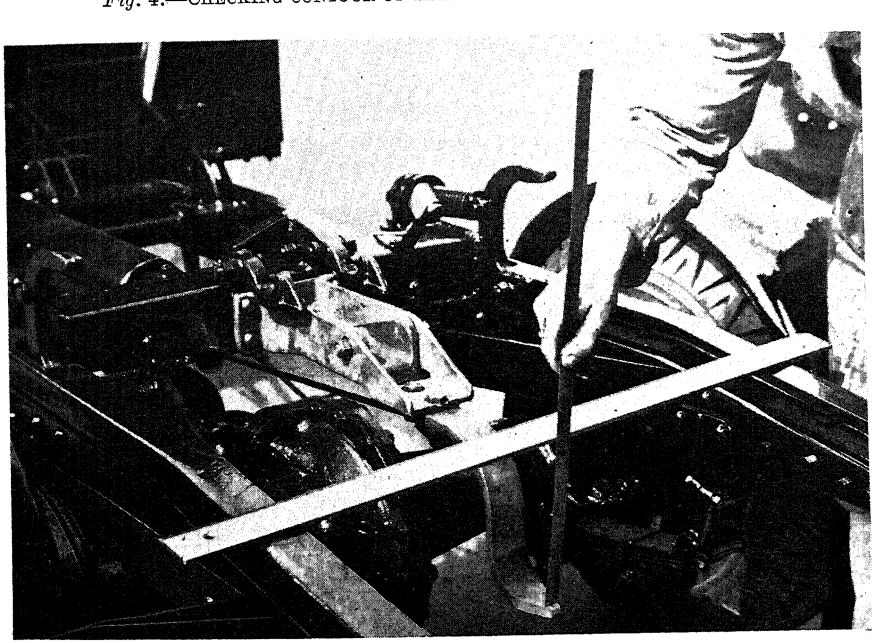


Fig. 5.—CHECKING CORRECT POSITION OF GUIDE BY MEANS OF RULE AND STRAIGHT-EDGE

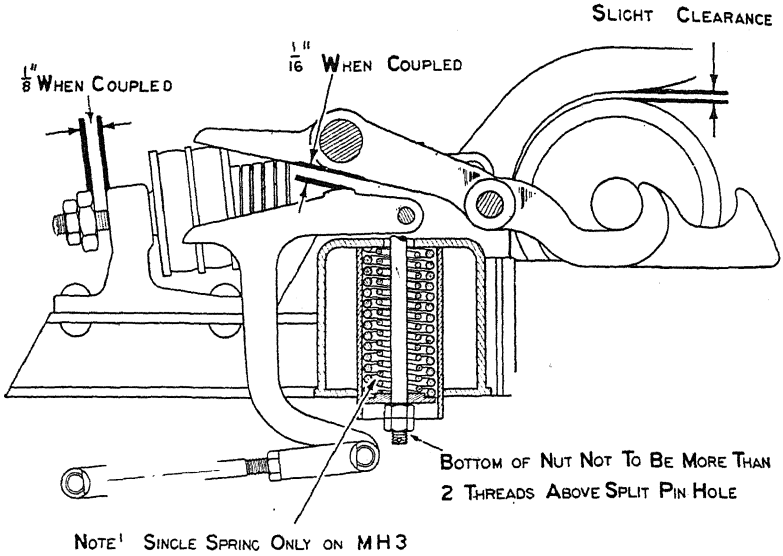


Fig. 6.—COUPLING GEAR ON MOTIVE UNIT, SHOWING NECESSARY CLEARANCES

M.H.6

Proceed as with M.H.3 with regard to transmission brake-drum fulcrum pins and fulcrum bracket. Take out the eight setscrews which retain bevel-pinion housing to gear casing. Screw two $\frac{3}{8}$-in. B.S.F. setscrews in tapped holes provided in flange to extract pinion housing, taking care to note the number of shims fitted under flange. Remove nut from splined end of bevel pinion, and take off driving flange ; a slight tap with a mallet on the pinion will drive out pinion and races complete.

In the event of oil leaking into the transmission brake drum, the fault will be found in the oil seal fitted into the fulcrum bracket. The fulcrum bracket should be removed as previously described and the oil seal gently tapped out, taking care to avoid damaging it. If the leather of the seal is in good order, coat the outside of the oil seal with jointing compound and tap it carefully back into position with the turned-up edge of the leather facing *inwards*, afterwards slightly peening the edge of the housing with a punch to hold the oil seal in position. The setscrews in the fulcrum bracket must not be pulled up too tightly or the bracket will distort, thereby allowing the oil seal to rotate and oil leakage to occur.

COUPLING GEAR AND UNDERCARRIAGE

The front portion of the carrier is fitted with a turntable, to which is attached a retractable undercarriage carrying two wheels which support the carrier and render it mobile when detached from the motive unit.

On the rear of the motive-unit frame are two ramps, or runways,

which are so shaped as to take the flanged wheels fitted to the transverse oscillating beam on the carrier undercarriage at whatever angle you may desire to couple the unit to the carrier. At the front end of the ramps are fitted two adjustable spring-cum-rubber buffers. These buffers take the shock of coupling up, and load the coupling hooks to keep the carrier securely locked to the unit.

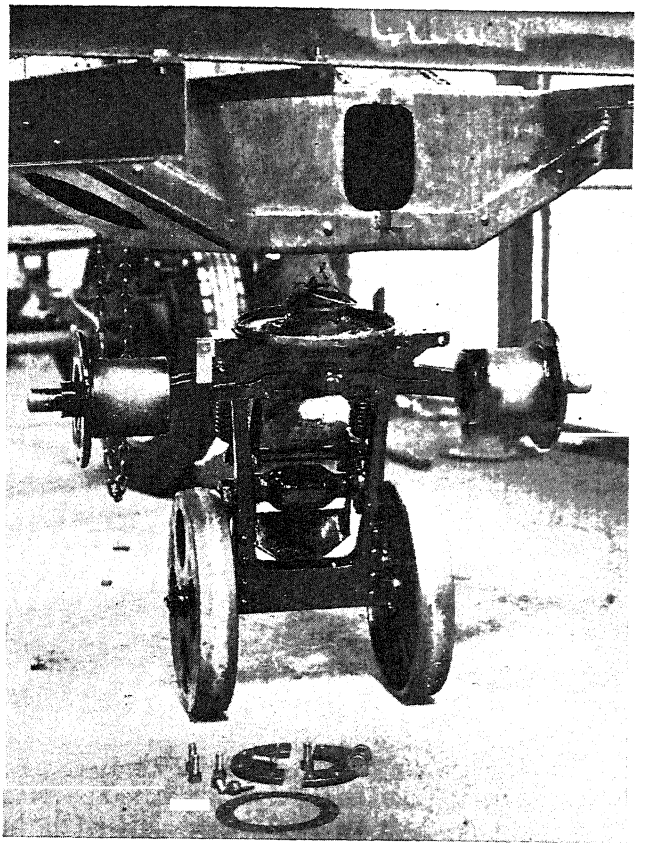


Fig. 7.—UNDERCARRIAGE REMOVED

Showing the horseshoe locking plates and shims for taking up excessive play.

Lubrication

Grease all joints on the undercarriage once weekly, and where no grease-nipples are provided give a few drops of oil. Lubrication of this assembly is of the utmost importance, since any tightness in the joints may cause collapse of the carriers, with consequent risk of personal injury.

The joints of the coupling hooks and operating gear must also be given attention with the oil-can at similar intervals to ensure ease of operation.

Adjustment of Buffer Springs

The locknuts in front of the buffer brackets should be set with $\frac{1}{8}$-in. clearance from buffer bracket when unit is coupled to carrier (*see* Figs. 3 and 6).

Correct Position of Guide

The guide should be checked for shape and position by means of the template provided (*see* Fig. 4), and also with a rule and straight-edge, for the purpose of ascertaining that the following dimensions are maintained (*see* Fig. 5).

M.H.3

Distance from rear cross-member of motive unit to point of guide—1 ft. 10 in. Distance from top of ramps to guide point—$7\frac{7}{8}$ in.

M.H.6

Distance from rear cross-member of unit to point of guide—2 ft. $3\frac{3}{16}$ in. Distance from top of ramps to guide point—$10\frac{5}{8}$ in. (*see* Fig. 5).

When the unit is coupled to carrier there should be a clearance of $\frac{1}{16}$ in. between the uncoupling cam and the bottom face of the locking hook on the motive unit rear cross-member (*see* Fig. 6).

Figs. 5 and 6 show the coupling-gear layout and some of the dimensions given above illustrated. On the later models a double locking hook has been introduced, which, used in conjunction with lighter buffer springs and a heavier twin-hook return spring, gives an increased safety factor when coupling up.

Removing Undercarriage and Turntable

Jack up front of trailer, disconnect the tail-lamp connecting wire inside the turn-table box-member.

Remove the pin which secures the brake-operating bellcrank to the locking plates. Take out the eight setscrews and remove the two horseshoe locking plates which secure the undercarriage to the box-member. The undercarriage may now be removed if the chassis is jacked up a little higher.

Taking up Wear

A rubbing plate is fitted to the underside of the box-member upon which the turn-table operates, and excessive wear on the undercarriage can be taken up by fitting shims of sheet steel between the rubbing plate and the box-member.

After shims have been inserted as above, turn-table should rotate evenly and without side play or rock.

When the unit is uncoupled from the carrier the undercarriage should immediately release and lower its wheels to the ground, and the spring catch lock round the pins protruding from the supporting arms.

Any failure or sluggishness in this operation is almost certain to be due to neglect in lubricating the various joints.

To rectify, either thoroughly spray with penetrating oil, or preferably

completely dismantle the undercarriage and ease all the pins. Clean all parts and grease well before reassembling. It is essential to uncouple the carrier at least once a week to inspect all joints and thoroughly lubricate the undercarriage.

Warning

Inexperienced persons should not be allowed to tamper with the under carriage when the carrier is uncoupled unless it is supported on trestles at its front end, as disturbance of the safety catch may cause collapse of the carrier, with consequent serious results.

THE CARRIER

This part of the vehicle is of such simple construction that no attention is required except regular lubrication of all parts, particularly the undercarriage, regular attention to the tightness of wheel nuts, and brake adjustment.

The carrier brakes are adjusted by means of the wingnuts on the balance-beam situated under the floor of the body.

In the event of its being necessary to remove the carrier hubs for brake relining or any other cause, remove wheels, hub caps, and axle nuts. Now withdraw the hubs with the same tool as used for the driving hubs. The brake shoes will now be exposed and can be removed without further trouble.

M.H.3

When refitting hubs, fill them with a liberal supply of grease and reassemble with bearings. Adjust by first tightening the locknut right up, then slacken back one-third of a turn, or two castellations, and insert split-pin.

M.H.6

In this case the locknut is also fitted with a clamping bolt and the axle is drilled with two split-pin holes. After tightening up the locknut, slacken back one and a half castellations before inserting the split-pin. Finally, retighten the clamping bolt.

REMOVING BODIES FOR FRAME REPAIRS

ALTHOUGH many repairs can be effected to the chassis without removing the body, this becomes necessary when frame repairs are required. As the modern body extends below the top of the chassis and the tank filler often passes through the rear wing or a part of the body, its removal is not so easy as with an older pattern of car, which has the bottom of the body level with the top of the chassis.

Preliminary Work—Dismantling the Body

To prepare the body for dismounting, the back cushion and all loose and fixed floor coverings are removed, then the front seats and all floor-boards. The rear wings are detached from the body and platform steps. The removal of the front wings and running boards is not always essential for dismounting, but may be necessary, according to the work which has to be done on the chassis. If the front wings are to be detached, then the wiring of any wing lamps is disconnected. Other wiring which has to be disconnected includes that of all electrical equipment of the body, such as roof and other interior lamps, cigar lighter, and screen wiper, also head and tail lamp and rear number plate.

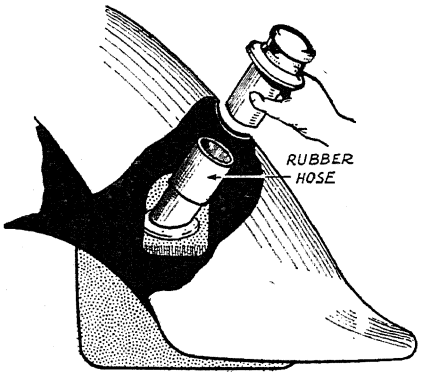


Fig. 1.—REMOVING THE UPPER PORTION OF THE TANK FILLER

This is sometimes connected to the lower part by means of a piece of rubber tubing.

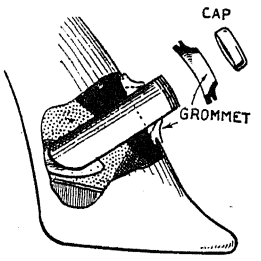


Fig. 2.—ANOTHER METHOD OF REMOVING TANK FILLER

In this instance the extended tank filler is in one piece and it is released for lifting the body by unscrewing the cap and removing the rubber ring or grommet.

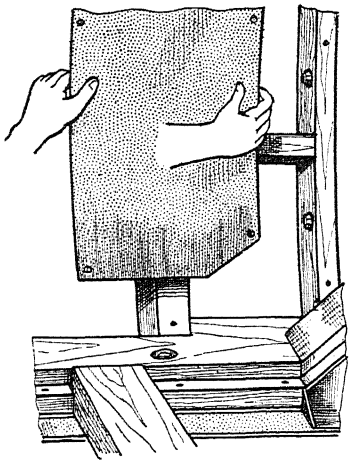


Fig. 3.—REMOVING THE INSIDE SCUTTLE PANEL

This is done in order to expose the side bolts which secure the front of the body to the dash.

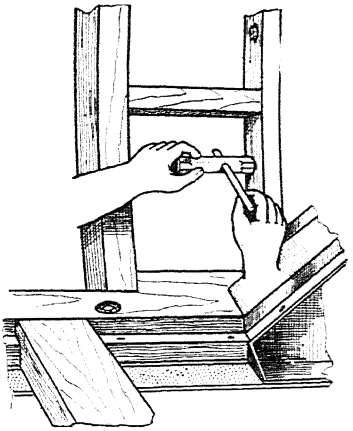


Fig. 4.—RELEASING THE BOLTS EXPOSED BY REMOVING THE PANEL SHOWN IN FIG. 3, WITH BOX SPANNER AND TOMMY-BAR

Facia Board, Control Levers, and Doors

The facia board is removed from its side brackets so that the instrument assembly remains attached by its own brackets to the dash. The brake and speed levers are arranged so as to form the minimum amount of obstruction to the body, which will be lifted vertically and to the rear, that is, the lever should be placed in an upright position. All doors are removed by driving out the hinge pins carefully with a drift. The hinge pins are replaced in the door half of the hinge so that they are not mislaid.

Releasing the Tank Filler

Attention is now directed to the tank filler. As a rule, this is one of two patterns. The filler may be extended by means of a rubber connection as shown in Fig. 1, so that the upper portion of the filler may be pulled out. If the filler passes through the wing, then the filler is, of course, detached before the removal of the wing. When the filler has no rubber connection but is a continuous metal tube, then it passes through an enlarged hole, as shown in Fig. 2. The clearance around this hole is concealed by a rubber ring or grommet, which can be sprung off by inserting the fingers under the rim at the edge, after the filler cap has been unscrewed.

Exposing the Dash Bolts

The body is held to the chassis by the bolts which pass through the side members of the frame or the mounting brackets, also by the bolts at the front which hold it to the dash. To expose all the dash bolts it is

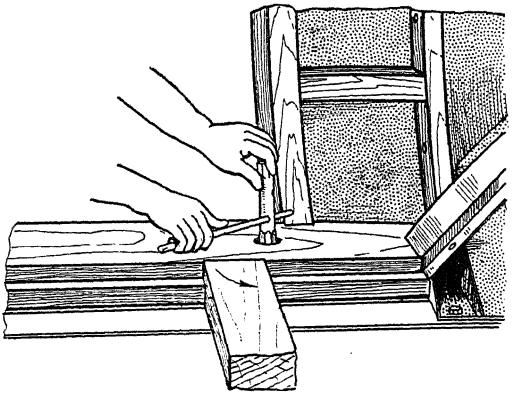


Fig. 5.—RELEASING THE HOLDING-DOWN BOLTS

usually necessary to remove an inside panel of plywood covered with leathercloth which is pinned or screwed to the side of the scuttle as shown in Fig. 3. The box spanner and tommy-bar (Fig. 4) will be required if the nuts of these bolts are recessed.

Removing the Holding-down Bolts

If the footboards which contain the pedal slots were not removed with the floorboards, these are now unscrewed, after which all holding-down bolts are released (Fig. 5.) The position of one of these bolts is shown clearly in the part sectional view, Fig. 6.

Preparing the Trestles

Before proceeding to lift the body, the necessary trestles which will form the temporary resting-place of the body are got together. The bottom of the body, whether a saloon, coupé, or open one, is higher under the wheelarch than in front, as shown in Fig. 11, therefore a pair of trestles should be available, one of which is about 6 in. higher than the other. It is an advantage if the body rests on these trestles horizontally so that the weight is properly distributed and the safety of the dismounted body ensured.

Dismounted Body should be Well Supported

Also, as the body is designed with a view to its shape being preserved by its attachment to the chassis, this shape is more likely to be maintained when it is removed from the chassis if similar means of support are provided. It is therefore an advantage if a third trestle can be placed under the centre of the body.

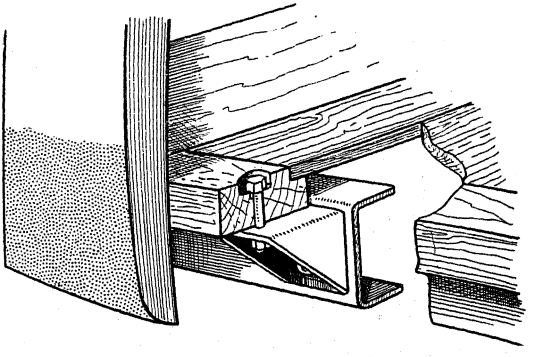


Fig. 6.—PART SECTION THROUGH CHASSIS AND BOTTOM OF BODY, SHOWING THE HOLDING-DOWN BOLT PASSING THROUGH THE BOTTOM SILL AND MOUNTING BRACKET

Instead of trestles a body-horse may be used, which is a low rectangular framework with lifting handles, or a trolley on castors. Lengths of timber of 2 in. by 2 in. and 2 in. by 1½ in. may be used to increase the height of the trestles or body-horse so that the body rests horizontally. These packing bars may be kept in position if a plate is screwed each side or encircles them so that overhanging lips are formed (Fig. 12).

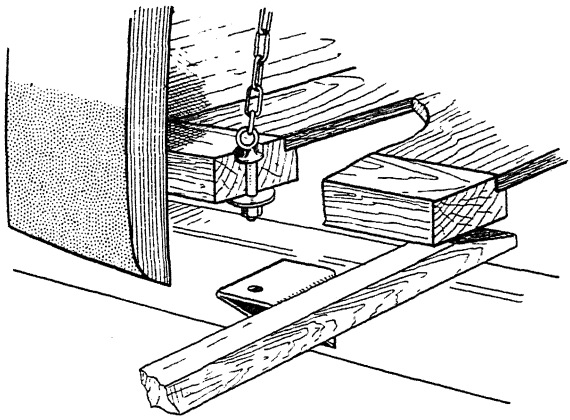


Fig. 7.—WITH THE HOLDING-DOWN BOLT REMOVED, THE HOLE IS THEN FREE FOR THE INSERTION OF THE RING BOLT OF THE LIFTING CHAIN

A large washer is placed on the underside. The ring bolt is inserted after the body has been raised and a bar of wood inserted.

First Stage of Lifting

The body must now be raised sufficiently to enable pieces of timber about 3 in. by 3 in. to be inserted between the bottom framework of the body and the chassis (Fig. 7). As the floorboards are removed, a convenient method of lifting the body for this purpose is for a man to step down inside between the chassis so that he may lift the body at a point where one of the cross bars joins the bottom side. The position of these crossbars is illustrated in Figs. 11 and 13. Another man lifts at the same point but on the outside, which will be at the foot of one of the pillars forming one side of a door opening.

Placing Two Bars between Body and Chassis

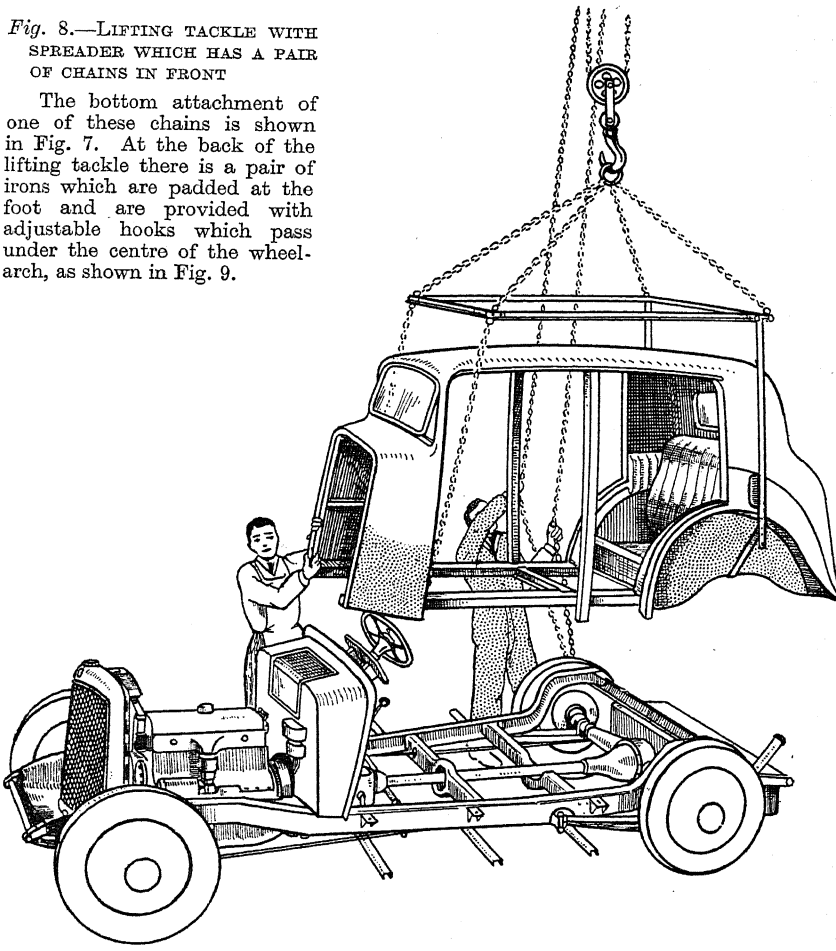
If sufficient men are available both sides may be lifted simultaneously, while another assistant inserts the length of timber. A pair of these bars are thus inserted, one in front close to forward edge of the door opening and the other under the centre of the wheelarch.

Lifting by Hand

If no lifting tackle is available, more men will be required, as the dismantled body will weight from 4 to 5 cwt. The pieces of timber which have been inserted under the body are used for lifting it. They should be long enough so that a man may lift each end. For a long and heavy body a third piece of timber is inserted at the base of the middle pillar of the body with a man at each end.

Fig. 8.—LIFTING TACKLE WITH SPREADER WHICH HAS A PAIR OF CHAINS IN FRONT

The bottom attachment of one of these chains is shown in Fig. 7. At the back of the lifting tackle there is a pair of irons which are padded at the foot and are provided with adjustable hooks which pass under the centre of the wheel-arch, as shown in Fig. 9.



Height of the Chassis

The body has to be lifted over the steering wheel, which is 3 ft. above the level of the top of the chassis or 4 ft. 6 in. from the ground level. The height the body has to be raised may be reduced a few inches by the removal of the steering wheel, the highest point then will be at the top of the instrument assembly. The actual amount the body has to be raised depends chiefly on the shape of the front of the body, and the wheelarch. In Fig. 11 the front of the scuttle is a plain arch, and usually the top of the steering wheel is only a few inches below it.

Lifting the Scuttle over the Steering Wheel

The body is lifted vertically for about 12 in., so that it is free at the base of the wheelarch. Then it may be lifted towards the rear, so as to clear the rear wheels, while, at the same time, the arch of the scuttle passes over the steering wheel. As a precaution the wooden bars which are used for lifting should be clamped or tied to the bottom framework.

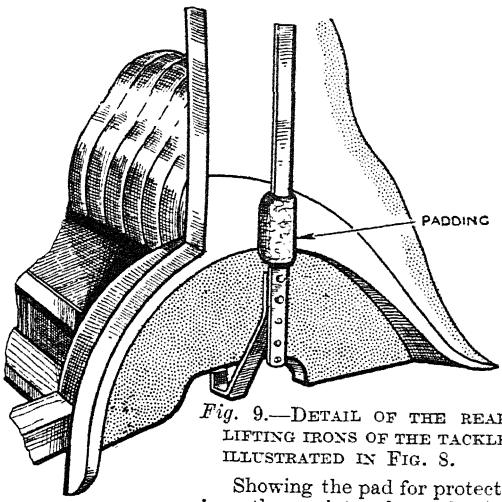


Fig. 9.—DETAIL OF THE REAR LIFTING IRONS OF THE TACKLE ILLUSTRATED IN FIG. 8.

Showing the pad for protecting the paintwork and the adjustable hook.

Lifting Tackle with Spreader

Most garages and repair shops, however, have some form of lifting tackle, which simplifies considerably the work of dismounting the body. This tackle should include a spreader, as shown in Fig. 8. This is made of $1\frac{1}{4}$-in. angle iron and is about 5 ft. 6 in. long and 5 ft. 6 in. wide. Each corner of the spreader has a ring for the upper chains, which are assembled to the lifting ring. At the two front corners of the spreader is another pair of rings for the attachment of the lower front chains. At the back of the spreader is a pair of $1\frac{1}{4}$-in. by $\frac{1}{4}$-in. irons about 3 ft. 6 in. long. These irons are swivelled at the top to the spreader and are padded at the lower end (Fig. 9) in order to preserve the paintwork. The pad slides on the iron, so that its position may be adjusted as required. Below the pad the iron is drilled with holes about an inch apart, so that a hook may be

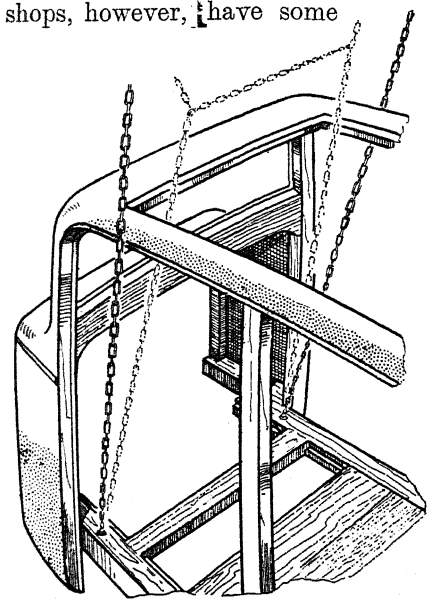


Fig. 10.—ALTERNATIVE METHOD OF LIFTING THE FRONT OF THE BODY WHEN IT HAS A SLIDING ROOF

The chains may be passed outside, as in Fig. 8, or inside as indicated by the dotted lines in this picture.

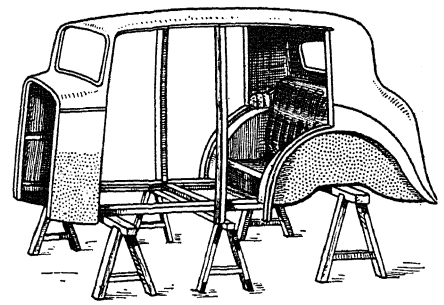


Fig. 11.—THE DISMOUNTED BODY RESTING ON ITS TRESTLES

The body should be adequately supported and in a horizontal position so as to prevent any distortion.

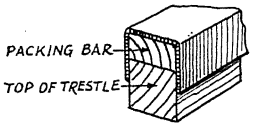


Fig. 12.—BAR FOR ADJUSTING THE HEIGHT OF THE TRESTLE

This bar has a plate screwed to it which forms lipped edges and keeps it in position.

bolted on the inside at the required height.

Attachment of the Tackle to Body

The lower end of the front chains are attached to the body by means of ring bolts and washers (Fig. 7). The same holes are used from which the holding-down bolts have been removed. The bolt end of the chain is dropped through the hole and bolted after placing the washer on the under side. The rear hooks and pads are adjusted at the rear so that the tackle when operated has the spreader in a horizontal position. The lifting should be done as close as possible to the position in which the dismounted body is to be placed, so that, after lifting and running the chassis from under it, the body may then be lowered on to its trestles or body-horse.

Lifting Body with Sliding Roof

If the front chains are apt to rub the sides of the body at the roof, a piece of canvas is wrapped round them. The body may also be lifted in front, if it has a sliding roof, by opening the roof and passing the front chains through the roof opening, as shown in Fig. 10. The spreader if too wide may be discarded and a short length of chain or a piece of rope used to draw the front chains together. The chains should be padded at the roof line so as not to injure the mounting of the sliding roof.

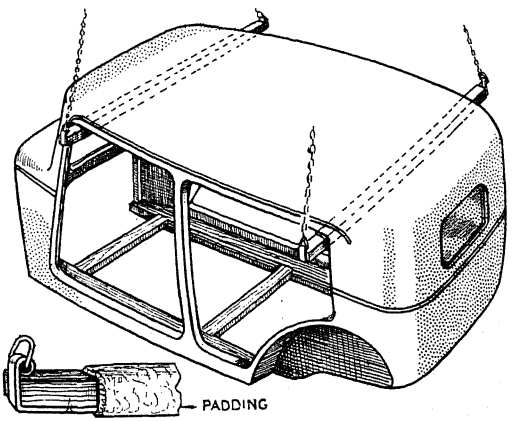


Fig. 14.—THE BARS SHOWN IN FIG. 13 ARE PLATED ON THE UNDERSIDE, PADDED THEIR FULL LENGTH AND FITTED WITH SHACKLES FOR THE ATTACHMENT OF THE LIFTING CHAINS

Fig. 13.—LIFTING A BODY WITH A PAIR OF BARS PLACED UNDER THE ROOF AT THE EXTREME FRONT AND REAR OF THE DOOR OPENINGS

Dismounting Bodies with Folding Heads

A body with a folding head, such as a drop-head coupé, cabriolet, or landaulette, may be lifted with the head closed when it is being lifted from above, as indicated in Figs. 8 and 10, but precautions must be taken by sufficient padding to ensure that the sides of the head are not rubbed by the rear irons, or that there is not any undue side pressure. Otherwise, the head should be folded and again raised when the body has been placed on the trestles.

Lifting at the Roof Level

Another method of lifting a body such as a saloon, but not a body with a folding head, is shown in Fig. 13. In this instance the lifting chains are attached to the ends of a pair of cross-bars $1\frac{1}{2}$ in. wide and 2 in. deep. They are stiffened on the underside with a $1\frac{1}{4}$-in. by $\frac{1}{4}$-in. plate, which is turned at each end, as shown in Fig. 14, so as to form an eye which takes a shackle for the chains. These bars are padded and are inserted in each door opening in the positions shown, that is, close to the front and rear body pillars respectively.

All-steel Bodies

This latter method will have to be used in the case of cars having all-steel bodies, as the light metal sill is generally insufficiently strong to stand the local loads imposed by the chain bolts.

THE MORRIS EIGHT CHASSIS AND BODY

SERIES E

THE SPRING MOUNTINGS

THE spring anchorage in the case of both front and rear springs on the Morris Eight, Series E, is effected by means of rubber bushes, which are provided, on either side, with fibre washers. Should side play develop at these bearings the fibre washers will need renewal.

Screwed-type shackle pins and bushes are fitted to the rear end of the front springs at both ends of the shackle plates, and to the *lower* end of the shackle plates for the rear springs.

Correct Adjustment of Shackles

When refitting the shackles, particularly when new parts are being introduced, it is essential that they be correctly adjusted with equal clearance on both sides. For this purpose Morris Motors supply special gauges under Part No. 67800, two of which are required.

When assembling the components, lubricate the threads of the shackle pin before screwing it into its bush.

Place one of the special gauges on the taper on each side of the screwed pin, and adjust the position of the pin so that each gauge just makes contact with the bush on each side. This ensures that the pin is exactly central.

The gauges are now carefully removed without disturbing the pin, and the felt washers placed on each end of the pins followed by the shackle plates.

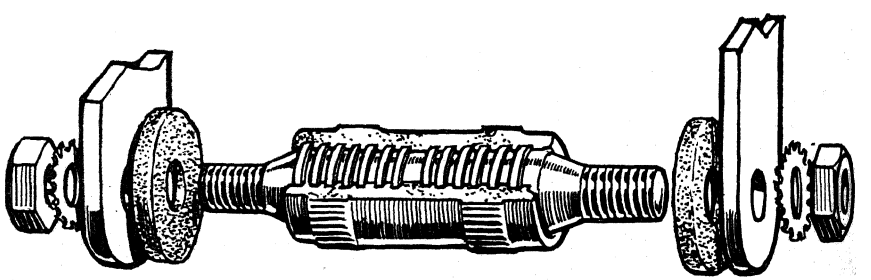


Fig. 1.—THE COMPONENT PARTS OF THE MORRIS SCREWED SHACKLE

Showing their order of assembly. It is essential that the screwed bush is located centrally on the shackle pin.

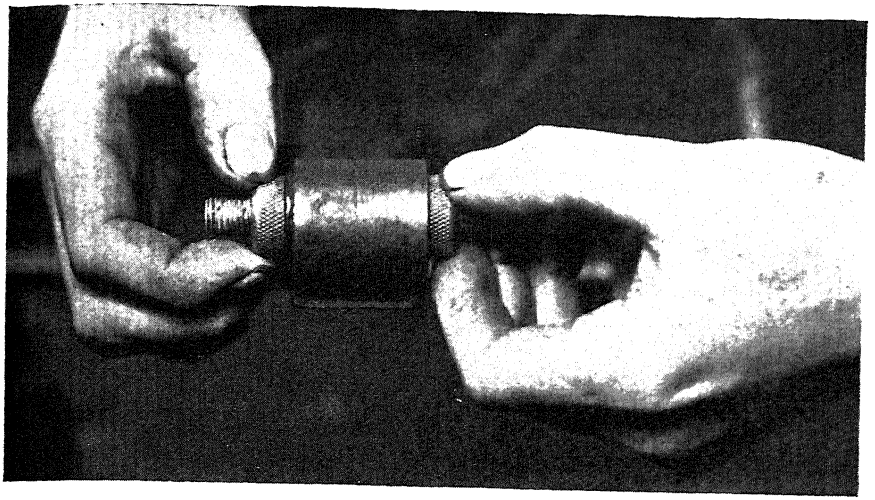


Fig. 2.—ADJUSTING FOR EQUAL DISTANCE ON BOTH SIDES OF SHACKLE

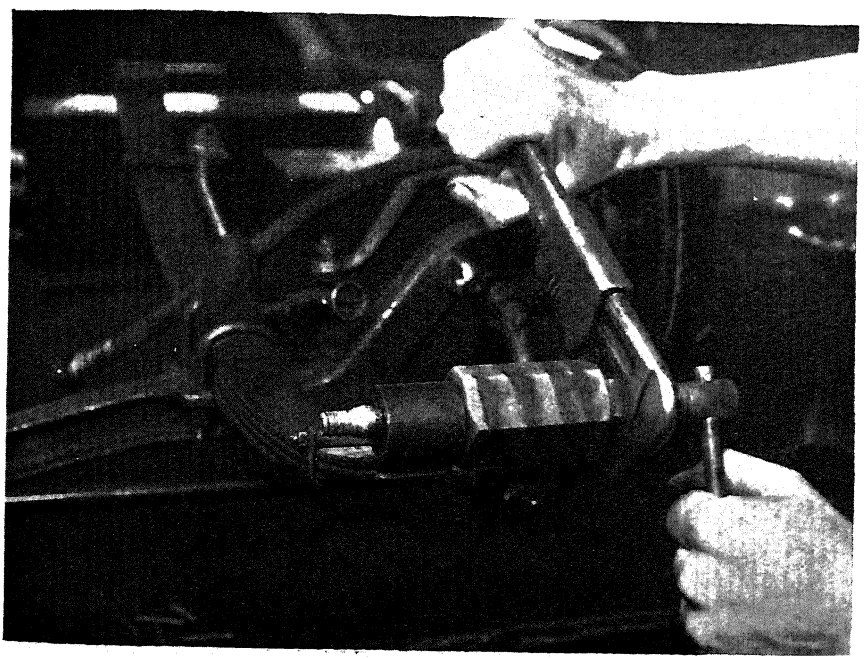


Fig. 3.—REMOVING BUSHES FROM REAR SPRING BRAC

Fig. 3A.—REMOVING RADIATOR SHELL

Fig. 3B.—REMOVING RADIATOR

Pressure should now be applied with a clamp to the sides of the shackle plates, so that they are firmly held in contact with the tapers on the pin. This will prevent rotation of the pin, while the shackle-pin nuts are replaced and tightened up. As an added precaution, see that the shackle-pin nuts turn freely on their threads.

Tighten up the shackle-pin nuts firmly, taking care not to turn the pin itself in the process, and do not forget the shakeproof washers under the shackle-pin nuts.

The upper ends of the rear spring shackles are attached to the frame by a high-tensile bolt supported in two special rubber bushes housed in the spring bracket.

Any new springs supplied by the makers are only fitted with the rubber bush at their anchorage end, so that new screwed bushes should be ordered at the same time if they show signs of wear.

Extraction and Replacement of the Special Bushes

The screwed bushes are pressed into the spring eyes and their extraction and replacement can be carried out with suitable distance-pieces in a press or large vice.

For the special bushes in the rear spring bracket a special tool has been devised by the makers to enable their extraction and replacement to be carried out successfully. This is obtainable from the Service Parts Department of Morris Motors, under Part No. 67849.

To Remove the Steering-column Assembly

First disconnect the battery positive cable by slackening the $\frac{1}{4}$-in. pinch bolt of the terminal lug and withdrawing the lug from the terminal post.

Drain the radiator by means of the drain tap provided in the radiator bottom tank, and release the hose clips of both top and bottom rubber hoses.

Release the hose-pipes from their connections and detach the radiator shell by removing the packing strip from under the bonnet webbing at the top of the shell, undoing the two bolts attaching the radiator shell to the radiator core, and unscrewing the ten setscrews attaching the radiator shell to the front wing valances.

Unscrew the two locknuts and brass nuts from the radiator core attachment studs passing through the chassis front cross-member, and withdraw the radiator core.

Disconnect the four wires leading out of the bottom of the steering-gear box from the special snap connectors provided, and unsolder the nipples from the wire, withdrawing the rubber sheathing.

At the bottom of the steering-gear box will be found a hexagon nut screwed on to the end of the centre tube. Unscrew this nut and carefully ease the protruding portion of the stator tube upwards through the centre tube of the gearbox end cover, taking care not to lose the locking olive. This will enable the stator tube with its trafficator-switch assembly to be withdrawn upwards into the body of the car for some 2 or 3 in.

The cheese-headed clamp-screw which attaches the baseplate of the trafficator-switch assembly to the stator tube is revealed. Slackening the clamp-screw enables the complete assembly with harness cable to be withdrawn.

Push the stator tube back into the steering column, and unscrew the steering-wheel retaining nut with a box spanner. This will enable you to remove the steering wheel with a suitable extractor.

Unscrew the bolts attaching the steering column to the facia-board tray, and release the Bowden-wire control bracket from the steering column, together with the accelerator-pedal bracket assembly.

Raise the offside front wheel clear of the ground and remove the wheel. This will give access to the steering drop arm, which should be released from the steering-gear box shaft, by removing the pinch bolt, and then withdrawn.

The electric horn will also have to be removed by undoing its two attachment bolts.

The two bolts attaching the steering-gear box to the front dumb-iron should now be withdrawn and the steering-gear box side cover should be removed complete with its packing shims and paper gasket, catching the oil released in a suitable receptacle.

This will permit you to extract the rocker shaft from the gearbox, but care must be taken not to lose the felt oil-retaining washer fitted to the rocker shaft on the outside of the gearbox.

The steering column and gearbox assembly can now be pushed into the interior of the car until the steering-gear box is clear of the brake pipe, when it can be lowered between the chassis side member and the engine and withdrawn forward from the underside of the car.

When reassembling, care should be taken to see that the drop arm is correctly replaced on the steering-gear box shaft, with the mark on the rocker shaft coinciding with the mark on the drop arm. Care should also be taken to see that the right number of shims are in position under the steering-gear box side plate when this component is replaced.

REMOVING SALOON BODY FROM CHASSIS

Remove the front seats by releasing the nearside-seat clamps and raising the offside-seat adjuster, and sliding the seat forward until it is clear of the runner.

Remove the rear seat and seat squab, the latter being released by the removal of the three round-headed wood screws, access to which is obtained through the luggage compartment.

Take out all the floor carpets, remembering that the front-seat steady clips must be removed before the rear carpet can be withdrawn. The steady clips are removed by unscrewing the two countersunk screws which are found in each

Disconnecting the Various Cables

Disconnect the battery cables from the battery by slackening the terminal lug pinch bolts and withdrawing the lugs from the terminal posts. Remove the battery by removing the two attachment bolts, noting that they are equipped with double coil-spring washers.

Disconnect the petrol-feed pipe from the petrol pump, and disconnect the petrol pump from the scuttle. Detach the white wire from the insulated terminal of the pump and the black wire from the other terminal, thus allowing the pump to be placed on the top of the engine during subsequent operations.

The ignition coil should be detached from the scuttle by removing its two attachment bolts, noting that the upper one is equipped with a nut and a spring washer, while the lower bolt forms the anchorage for the engine-earthing cable and screws into a clinch nut, being prevented from working loose by a spring washer.

Release the high-tension cable from the central terminal and release also the two white wires from the terminals on the body of the coil marked "S.W.," and the wire coloured brown and white from the terminal marked "C.B."

The junction and control-box unit can be removed from the scuttle by undoing the two round-headed attachment screws, without disturbing the wires connected to it. It should be noted that a rubber washer is fitted to each attachment screw between the base of the control box and the scuttle.

Release the starter cable, together with the battery cable and the yellow and black wire from the starter switch, by undoing the terminal nuts.

Release, also, the two leads from the windscreen-wiper motor, making a note that the green-and-purple wire is attached to the terminal nearest the scuttle. Now pull the two wires through from the inside of the scuttle and release the black wire which is attached to one of the fixing screws for the chassis identification plate.

The Instrument Panel Wires

Remove the instrument panel in the manner indicated in Vol. IV, and release all wires connected to it, making a note of their points of connection for replacement purposes.

The wires concerned, looking at the back of the panel, are :

(1) The yellow wire for the ignition warning light.

(2) The black wire attached to the speedometer support frame.

(3) The white wire attached to the centre terminal of the switch-box.

(4) The blue wire attached to the right-hand bottom terminal of the switch-box.

(5) The black-and-white wire attached to the centre bottom terminal of the switch-box.

(6) The three red wires attached to the left-hand bottom terminal of the switch-box. (Note that the fourth and uppermost terminal at the bottom of the switch-box has no connections.)

(7) The two black wires attached to the instrument attachment frames.

(8) The purple-and-blue wire leading to the upper petrol-gauge terminal.

(9) The purple-and-black wires leading to the lower petrol-gauge terminal.

Now detach the windscreen-wiper blade from its spindle by slackening its locking screw, and withdraw the rubber seal. Release the wiper spindle and switch assembly from its bracket by removing the two round-headed attachment screws, and unsolder the wires from the switch-terminal clips, making a note that the green-and-purple wire is attached to the top and the black wire to the bottom.

The harness cable and speedometer cable can now be withdrawn from the scuttle, from the engine side, after the harness clip has been released from the underside of the tool-box.

Part the two trafficator wires by separating their snap connectors which are to be found under the rear offside floorboard. The protecting cover should be removed from the top side of the floorboard and the ends of the wires should be drawn up into the body.

Disconnect the tail-lamp and stop-lamp wires from the lamp terminals, noting that the purple wire is connected to the stop lamp and the red wire to the tail lamp, while the black earth wire is, of course, attached to the earth-terminal clip.

The bonnet should now be removed by unscrewing the two fixing bolts attaching the bonnet to the hinges, and placed in a position where it will not be damaged.

Tray below Facia-board

The tray below the facia-board should be removed by unscrewing the two bolts from the steering-column steady bracket, removing the fixing screw with raised head from the centre support for the tray, extracting the seven bifurcated rivets attaching the tray floor to the front rail, and unscrewing the setscrew and bolt attaching each end of the front rail to the side of the body. This will enable the tray front rail to be withdrawn after the trimming at each end of the rail has been detached and folded down to clear.

Slacken the locknut of the gear-box knob, unscrew the knob, and then pass the rubber gearbox cover over the lever.

The nearside and offside floorboards are next removed by unscrewing the series of countersunk screws with dished washers, and the foot-operated dipping switch is also removed by unscrewing the two round-headed attachment screws.

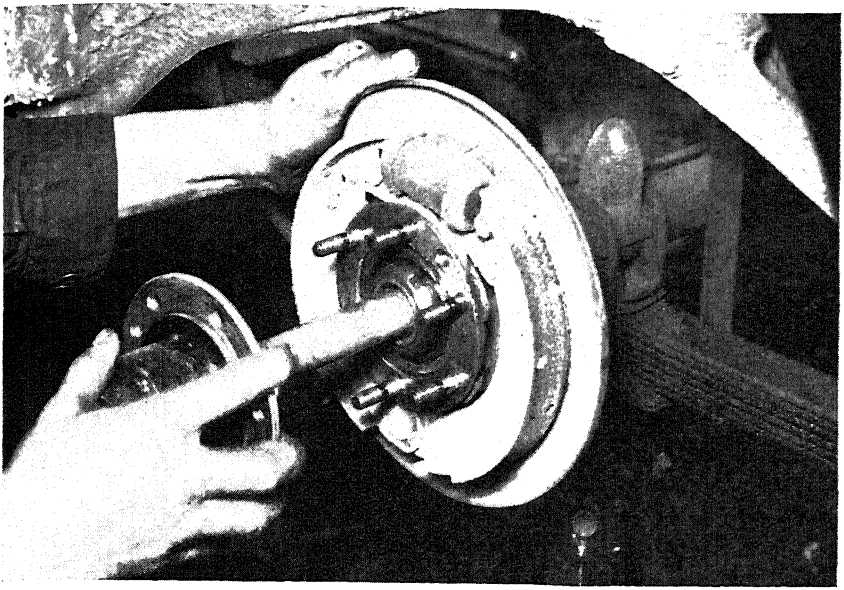


Fig. 4.—REMOVING AXLE SHAFT

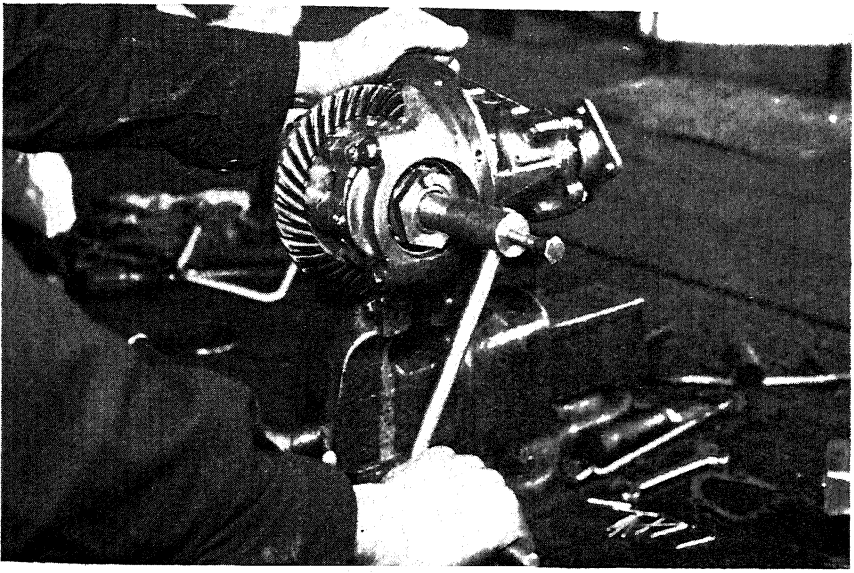


Fig. 5.—ADJUSTING DIFFERENTIAL ASSEMBLY

The Karhyde draught strip should be released from the side of the body.

The offside toe-board may now be released by unscrewing the six countersunk fixing screws with dished washers, and the dipping switch may also be removed by unscrewing the two round-headed attachment screws.

The nearside toe-board, together with the gearbox-shield assembly, can then be detached by unscrewing the six countersunk (with dished washers) and the one round-headed attachment screws.

The opening below the steering column is closed by a small metal plate, which should be detached by undoing the two retaining screws with dished washers.

The three bolts attaching the scuttle side panel to the bonnet valance on each side should now be removed, together with the four bolts which secure the rear portion of the front wings to the body.

The rear bumper bar also needs removal and this is accomplished by releasing the small metal plates covering the bumper-bracket bolt holes on the underside of the wings. These plates have keyhole-type slots which enable them to be removed without completely unscrewing the attachment screws. The bumper-bracket bolts are now exposed and can be unscrewed by means of a box spanner, permitting the withdrawal of the bumper rearwards.

The Body Attachment Screws

Attention should now be given to the body attachment screws, eight of which locate the body to the frame member on each side, and three attach the rear of the body to the rear chassis cross-member. In addition there are eight bolts on each side which attach the lower flange of the body sill and wheelarch to the bottom flange of the chassis side member.

Before removing the body it is necessary to release the petrol-tank filler by slackening the hose clip inside the luggage boot and withdrawing the fillers from the side of the body.

While it is by no means essential to remove the rear wings, it may sometimes be wise to do so in order to avoid damage if the removal of the body is carried out in a restricted place or with meagre equipment.

How to Lift the Body

The body is best removed from the chassis by the help of four men provided with suitable lifting poles which can be passed under the body if the rear end is first raised a short way for the insertion of the rear pole over the centre of the rear wheels, and the front end then raised for the insertion of the forward lifting pole just to the rear of the handbrake-lever bracket.

With one man at each end of the poles the body should be lifted clear of the chassis and walked backwards, taking care to see that the body clears the steering wheel.

Reassembly

Reassembly is carried out in the inverse order to removal, and it is essential to see that the scuttle side panels go right up against the bonnet valances, and to replace the three bolts on each side and tighten them up before making any other attachments.

It is also important to make sure that the electrical connections are correctly remade, remembering that the positive-earth system of wiring is employed.

ROVER REAR AXLES

By F. G. HAWKINS

BEFORE dealing with the question of servicing Rover rear axles, it would be as well if we make ourselves familiar with the various types used from 1934 to 1940. If we ignore minor modifications that have taken place from time to time, the axle assembly can be divided into three main groups, the first of which was fitted to all models from 1934 to the middle of 1937.

Axle Assembly up to 1937

As you will see from Fig. 1, the axleshaft (47) is fitted with a loose hub (50) fitted to a taper shaft, and that the axle and float are controlled by shims (44)—it is most important to remember this because, as will be seen later, it is not always so, and you are asked to notice particularly several other points also because they, too, vary considerably in the next two groups.

On the inner side of the hub assembly a Gitts oil seal (46) is fitted, and on the outer side a cork ring (49) prevents the escape of grease.

The differential consists of a differential case (8) to which the crown-wheel (7) is *riveted*, the whole being mounted on two tapered roller bearings (16), and adjustable locknuts (17) are provided by means of which the correct amount of backlash between the crown-wheel and pinion can be obtained.

Finally, we have two differential wheels (9) carried one on each of the splined inner ends of each axleshaft, and two differential pinions (10) carried on the centre spindle (11). Notice particularly that this centre spindle can be removed without disturbing the crown-wheel, because that point has a great bearing upon the question of the axle service on later models.

The bevel-pinion assembly is carried by two bearings (20) and (23) in the pinion housing (15), the rear of which is carried by two spring clips (21) and is separated from the front bearing by a distance-piece (24). The front bearing is carried in a bearing housing (22), and shims (29) and (30) are used to obtain correct location. The whole is locked up on the pinion shaft (6) by a nut and lock-washer (25) and (26), and the assembly is retained in position by an end cap in which is carried a Gitts oil seal (27) and (28).

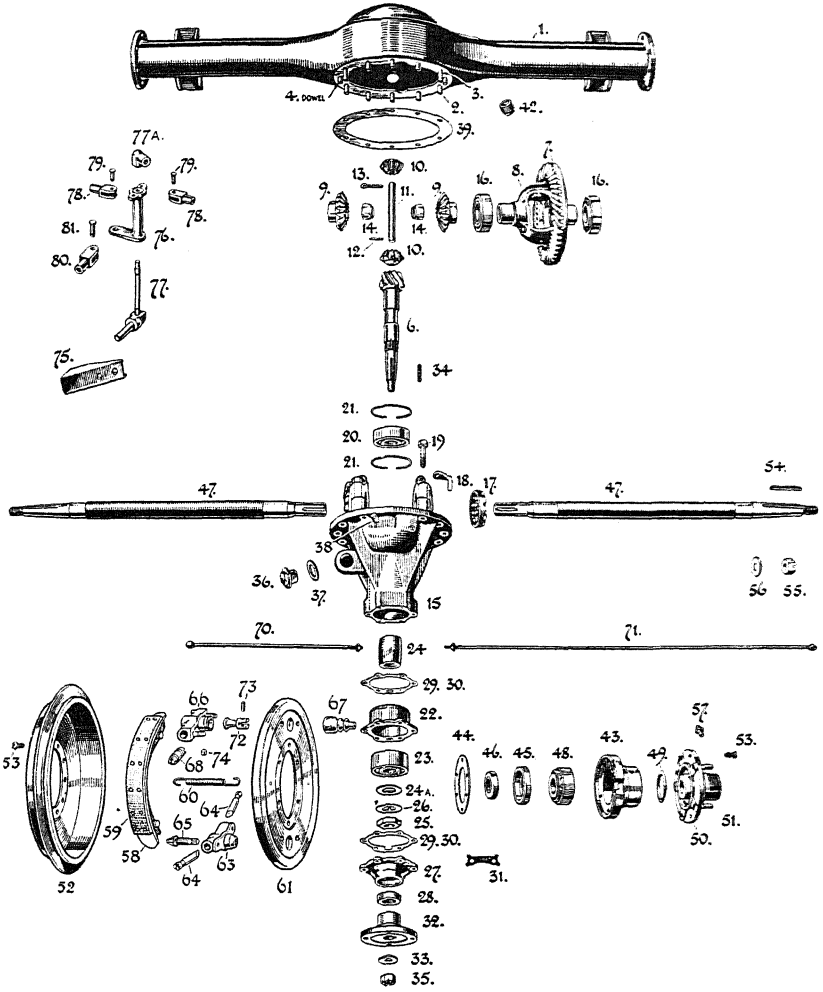


Fig. 1.—AXLE ASSEMBLY FITTED TO ALL MODELS FROM 1934 TO THE MIDDLE OF 1937

Axle Assembly, 1937–9

Now we will examine the second group (Fig. 2). All axles in this group were used from the second half of 1937 on 10-, 12-, and 14-h.p. models, and from the first car on all 16-h.p. and 20-h.p. models.

Apart from a few minor details, the differential and bevel-pinion assemblies are as on previous models, but the axleshaft assembly has been

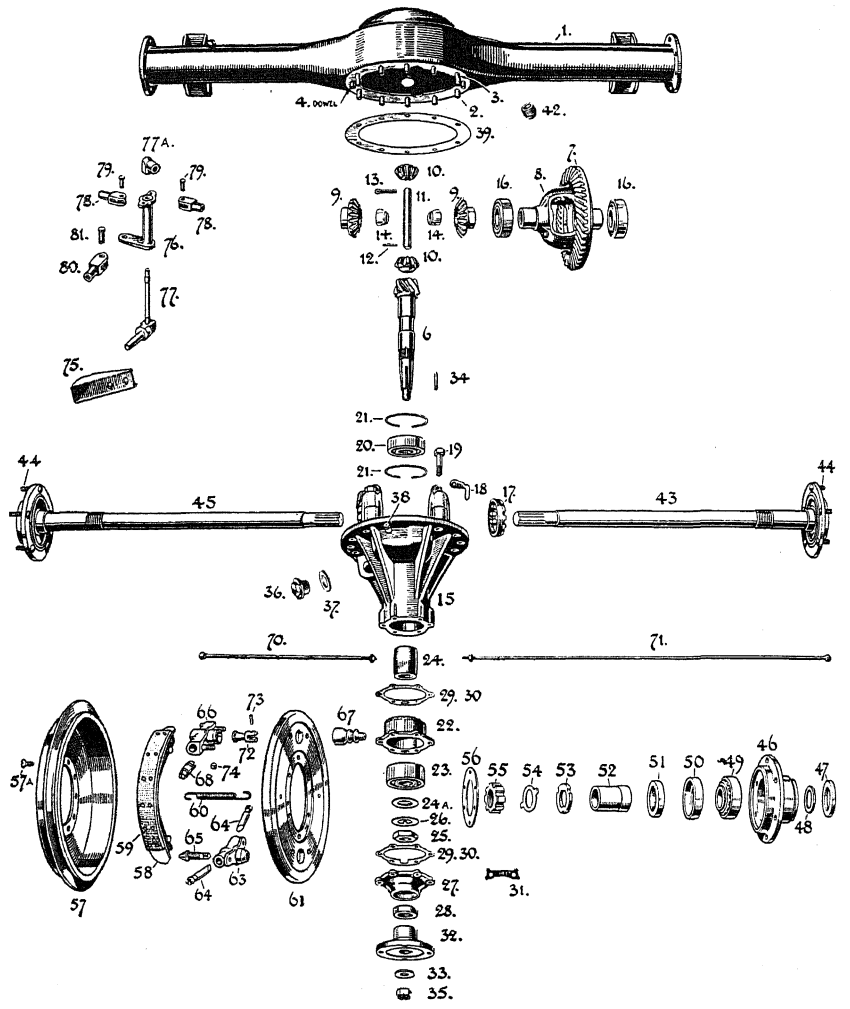


Fig. 2.—AXLE ASSEMBLY USED FROM THE SECOND HALF OF 1937 ON 10-, 12-, AND 14-H.P. MODELS AND FROM THE FIRST CAR ON ALL 16-H.P. AND 20-H.P. MODELS

completely redesigned, the hub no longer being loose but forged in one piece with the axleshaft; therefore the only part of this axle assembly we need to reconsider is the axleshaft.

As was formerly the case, end float is controlled by shims, but the cork ring on the outer end has been replaced by a Gitts oil seal (47), while the inner oil seal has been retained.

Axle Assembly, 1939–40

The third group of axles will be found fitted to all 1939 models with the exception of the first 3,000, and all 1940 models. As you will see by consulting Fig. 3, there are considerable alterations at several points.

First of all take the differential assembly; this is now offset to the extent of $\frac{5}{8}$ in.; the reason for this is to obtain equal loading on both bearings, a state of affairs that did not exist before, and it results in a much quieter axle, but its effects upon servicing methods is considerable. For instance, axleshafts are *no longer* interchangeable between nearside and offside, as was formerly the case, because one is now longer than the other. If it becomes necessary to fit a new shaft at any time, make sure that the correct one has been obtained or much time will be wasted. If the long shaft be fitted to the short side, it will not be possible to bolt it right home and the error will be quickly discovered, but if the short shaft be fitted in place of the long one it will bolt home, but will not drive, and the fact will not be discovered until it is attempted to drive the car.

Dismantling

Another point to remember regarding differential assemblies in this group is the effect the offset crown-wheel has upon the question of dismantling. It will be remembered that groups 1 and 2 had the crown-wheel secured to the differential case by rivets; it has now become necessary to dispense with these and use bolts instead; this is because the position now taken up by the crown-wheel prevents the removal of the differential wheels and pinions until the crown-wheel has been removed in order to clear the centre spindle—hence the use of bolts.

Early types of this assembly use a series of bolts and two dowels, but on later assemblies two fitted bolts take the place of dowels. A word regarding the fitting of a new crown-wheel to the differential box would not be out of place here.

When a crown-wheel is fitted originally by the makers, the series of ordinary bolts are fitted first and then the holes for the fitted bolts are reamed to suit. This method cannot be used when fitting a replacement crown-wheel, for obvious reasons, so fit the fitted bolts first and the ordinary bolts afterwards. The same remarks apply where dowels are used.

In the axleshaft assembly lies the biggest alteration in this group; it will be noticed that the securing nut on the inner end has been dispensed with, the outer oil seal has gone, as have also the shims and thrust-pieces.

Assembly of Axleshafts

The type of axleshaft assembly used in group 1 is too well known to require assembly instructions, so we will deal only with groups 2 and 3.

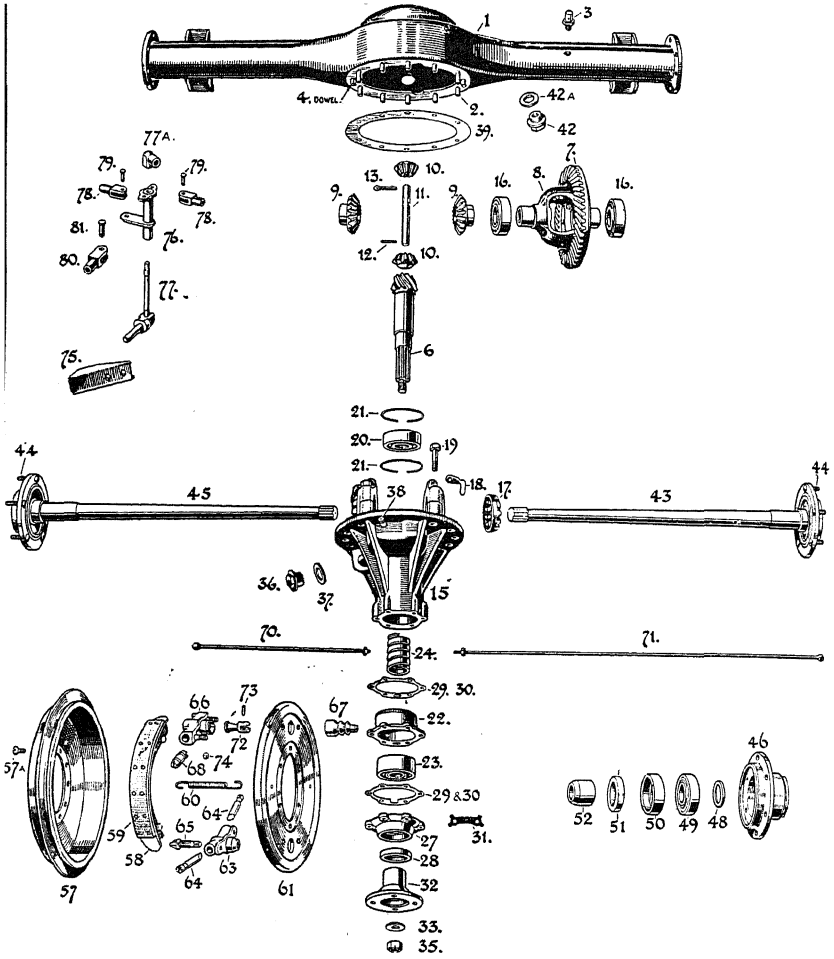


Fig. 3.—AXLE ASSEMBLY FITTED TO SOME 1939 AND ALL 1940 MODELS

Axleshaft Assembly, Group 2

Press taper-race outer ring (49) into housing (46) and fit the oil seal from opposite side (knife edge inwards).

Fit the anchor plate to the housing (six bolts), fit the inner oil seal (50) into housing (51) (knife edge outwards), fit the distance-washer (48) (chamfered edge towards hub) on the axleshaft.

Fill the bearing housing with grease and fit it over the axleshaft. Press the inner race, followed by the sleeve (52), into housing and press

the whole assembly right home. Fit the oil-seal housing (knife edge towards differential). Fit lockring tab washer and locknut.

When fitting the shaft to the axle case, return all shims as originally fitted and then check over for end float. If anything more than bare perceptible float is present, it must be removed by removing shims to suit. It will be found that shims are fitted of varying thicknesses from ·005 to ·064 in., thus enabling this to be done. On the other hand, if the shaft is butting or pinched, there will be a tendency for both shafts to turn in the same direction if one is turned. In that case, add shims as required until a correct balance is found, and a differential action results when one wheel is turned. If too much end float is present a " clonk " will be heard when cornering or when picking up from overrun to drive, and should a complaint of that nature be made the axleshaft end float should be checked and reduced to the smallest amount that can be detected, which will be approximately ·005 in.

On some models in this group, it will be found that two distance-sleeves are fitted, because the axleshaft was modified in such a manner that the threaded portion was moved back several inches.

Axleshaft Assembly, Group 3

This assembly is built up in the same way as in the previous group, but the whole is retained by a sleeve (52), which is a press-fit. A pressure of 2–6 tons is required to do this, so it is of no use attempting to assemble unless the right equipment is available ; by far the best method is to obtain a replacement assembly.

When bolting up the assembly to the axle sleeve the question of end float can be ignored, as the axle ends cannot butt, and as a ball race instead of a roller race is fitted, thrust is taken on the ball race. This is a point that should always be remembered, or much time will be wasted.

Bevel-pinion Assembly

The final alteration to be noted on the third group concerns the bevel-pinion assembly ; as you can see (Fig. 3), the taper on the pinion shaft has given way to splines. A coil spring takes the place of the distance-piece, and the locknut and washers have been dispensed with.

The instructions concerning assembly are as on the old pattern where the retaining nut was used.

Assembling of Bevel Pinion

There should be little difficulty experienced in assembling the bevel pinion if the various illustrations are consulted, but there are one or two points to remember.

First of all on the old type, with the taper-pinion shaft, remember to

lap the propeller-shaft flange to the taper on the pinion shaft, thus ensuring a good fit. If this is not done a " clonk " will develop when taking up the drive, indicating relative movement between the shaft and flange.

Secondly, when fitting the front end bearing remember that two types have been fitted from time to time. The most frequently used is Skefko bearing, and it is of the pre-loaded pattern ; the other is a Hoffmann split bearing, and it will need pre-loading by the manipulation of shims.

Proceed in this way :

Press the bearing (23) into its housing (22), making sure that it goes right home ; then check with the aid of a faceplate and feeler gauges to what extent the bearing stands proud of its housing.

Whatever this measurement may be, select shims to the *same* thickness if the bearing is of the pre-loaded type, or, to the same thickness minus ·002 in. if the bearing requires pre-loading, these shims to be subsequently inserted between the end cap and the bearing-housing flange.

Having dealt with these points, proceed to assemble as follows :

Fit the split-ring (21) into the pinion housing, followed by the outer ring of bearing (20), and the second split-ring. Press the inner ring of bearing (20) on to bevel pinion, followed by the distance-piece (24) or spring, whichever the case may be, and bearing housing (22) already assembled with bearing (23).

On the old pattern, the washer, lock-washer, and nut (25) follow ; see that the nut is really tight, and do not use a second-hand lock-washer.

Enter the assembly from the front end, together with the same quantity of shims between the pinion housing and the bearing housing (22) that were fitted in the first instance.

Now fit the oil seal (28) into cap (27) and bolt them up loosely to the pinion housing, together with the pre-selected shims between.

Finally add flange (32), and lock up securely.

FINAL ADJUSTMENTS

Tooth Markings

There now remains the job of adjusting for correct tooth contact ; this is a highly specialised job. It is dealt with by the manufacturers in a silence room and by a highly experienced man. In a book kept for the purpose he keeps a record of all tooth markings, a perfect example of which would show a marking extending from the toe (inner) end of the tooth, three-fifths of its length towards the heel (outer) end of the tooth, and being equidistant between top and bottom of the tooth.

It must be remembered at this stage that correct tooth contact, together with correct backlash, must be the object of any adjustment, and *not* the degree of noise.

Finally, we will go through the available adjustments to make sure there is no misunderstanding.

Differential Adjustment

There is one adjustment provided for moving the complete differential sideways—this is done by rotating the two large serrated nuts, one either side of the crown-wheel, in the required direction—one serration is equal to ·005 in. more or less backlash between crown-wheel and pinion, and it will at the same time raise or lower the tooth bearings. Once this has been correctly adjusted to give ·007 in. backlash and a tooth bearing equidistant between top and bottom of tooth it should never need altering, *not even to correct noise*, as that fault would not lie there.

Pinion Adjustment

The other adjustment is obtained by manipulation of shims at the tail shaft, and its effect is to move the pinion away from or towards the centre of the crown-wheel. The effect of that movement is to increase the lengthwise tooth bearing—towards the heel if the pinion is moved out, and towards the toe if the pinion is moved in. Again it is emphasised that correct tooth lengthwise bearing of three-fifths the length of the tooth, commencing at the toe, must be maintained, or rapid wear of the crown-wheel teeth will take place at either the toe or heel end, according to which way the error lies.

THE TRIUMPH CHASSIS AND BODY

By H. W. ALLISON

Hubs

HUBS are carried on tapered roller bearings, adjustment of the front ones being effected by removing the wheel, which exposes the hub nut. The split-pin is then withdrawn through the hole in the side of the hub and the nut tightened with a box spanner. The tightening should be done with great care, as it is otherwise easily possible to damage the bearings. The wheel should revolve freely, but at the same time there should be no sideways play.

Adjustment of rear hub bearings is a little more complicated, and in this case the wheel must be taken off and the hub pulled off with a drawer. The bearing housing will then be exposed, and this can be removed by taking out the six bolts attaching it to the axle case. Shims of varying thickness will be found behind the housing, and the removal of one or more of these is necessary to cure end play in the shaft. Adjustment is by trial and error, and after removal of the shim, the hub and wheel must be refitted and tested. Here again, it is important to ensure that there is no tightness.

Brakes

These are the Lockheed hydraulic type, and here it is necessary to deal only with shoe adjustments.

The hexagonal heads of the brake-shoe adjuster cams will be found on the backplates of the drums, and clearance between linings and drums is taken up by turning the heads outwards.

Brake squeal may be due to the shoes canting outwards and rubbing the drum, when the brakes are applied, and the cure for this is to fit an additional or, alternatively, a thicker washer on the brake-shoe steady pin.

A fierce brake is sometimes caused by the lining digging into the drum, and the remedy for this trouble is to " back off " or chamfer for about an inch or so the leading edge of the offending lining.

The hand-brake is cable operated, and acts on the rear wheels only. Adjustment is effected by rotating a wingnut which will be found underneath the car, to the offside of the transmission coupling shaft. Equalising adjustment is provided at the cross-shaft end of each cable.

Frequent lubrication of the exposed joints of the hand-brake mechanism is advised, otherwise rusting and stiffness will result.

Steering

The steering box is not adjustable, neither are the steering joints of recent models.

Steering-column Rake and Length Adjustment

The steering-column rake of all models is adjustable, and except for the very early Gloria models, so is the length.

Rake adjustment is effected by slackening off the bolt which holds the column to the scuttle bracket, likewise the two steering box-chassis frame bracket bolts. The column can now be raised or lowered as desired, and the bolts tightened. The chassis bracket bolts are wired together, and the wire should be refitted when the tightening has been completed.

Alteration of the length of the column can be effected after slackening off the slotted nut at the bottom of the steering-wheel boss, by pulling up or pushing down the wheel, as required.

Rattle in Steering Head

A rattle sometimes develops in the steering head, which is caused by movement of the steering-column control-plate assembly.

The cure is simple, and consists only of tightening the two or, in some cases, three grub-screws, which will be found recessed in the boss of the steering wheel. These screws bite on a plate which forms part of the control assembly, and which is housed in the boss.

Steering Wobble—Causes and Cures

Steering wobble, or wheel "patter," may be due to one or more of a variety of defects, these including inefficient front shock absorbers, flattened front springs, worn front-axle swivel pins and bushes, slackness in steering connections, play in front-wheel hub bearings, or unbalanced front wheels.

Balancing Wheels

A simple method of balancing a wheel is to remove all the grease from one of the front-wheel hubs, push the wheel on the hub splines, and rotate it. If out of balance, the wheel will swing before coming to rest. To correct the balance, weights should be attached to the spokes and, as nearly as possible, to the wheel rim, directly opposite to the heaviest and, therefore, lowest point of the wheel. Strips of lead, the total weight of which equals that of the temporary weights, should then be wrapped round the nipple or rim ends of the spokes, and secured by adhesive tape. A neat job is ensured by attaching the lead to the inner spokes, where they are less noticeable, and painting to match the colour of the wheel.

A trial-and-error method of determining the weight necessary to correct the balance is, of course, necessary, and a correctly balanced wheel will come to rest at any point without any swinging motion.

Side Play in Front-spring Shackles

A click, noticeable when turning on full lock, will be caused by the development of side play in the front-spring shackles, and the cure is to fit shims to the spring pins.

Front-wheel Alignment

Excessive or uneven front-tyre wear is an indication of the necessity for checking the alignment of the front wheels. These should be "toed-in" to a maximum of $\frac{3}{16}$ in. and a minimum of $\frac{1}{8}$ in. Measurement should be taken at the hub height, and between the wheel rims. The track rod is adjustable for length, the ends having right- and left-hand threads, and after slackening off the locknuts, or, in the case of recent models, releasing the pinch bolts, the rod may be rotated to increase or decrease the length.

This note applies also to the drag link, should it ever be found necessary to make an adjustment here.

Removing Front-axle Swivel Pins

Removal of the front-axle swivel pins and phosphor-bronze bushes is effected by removing the swivel-pin cotters, and driving the pins, and then the bushes, out from underneath. The installation of an automatic chassis-lubricating system necessitated the fitting of a screwed plug in each bottom bush from 1938 onwards, and these must be taken out in order to expose the bottom of the pins. These plugs should be filled with grease before refitting.

It is advisable to ream the new bushes after fitting, and the best method is to fit and ream the bottom bushes first, and then do likewise with the top bushes. A reamer piloted by the top bush hole should be used for the bottom bushes, and another piloted by the reamed bottom bushes for the top ones.

It may be found, owing to lubrication having been neglected, that the pins are so badly seized in the axle-pin holes that removal in the manner described above is difficult. If a thorough soaking with penetrating oil fails to help matters, time and trouble will be saved by taking out the axle complete, inverting it, and driving out the pins from the top. In this way considerably more force can be applied to the driver.

Removing Front-axle Assembly

Removal of the axle assembly is comparatively straightforward, the procedure being to raise and support the front of the car on a cradle placed under the engine flywheel housing, disconnect the drag link at the drop-arm end, and the brake and oil pipes at the nearest frame junction. Then the axle shock-absorber arm bolts and lastly the spring "U"-bolt nuts are removed. Two small points are worth noting, the first being

that there may be insufficient room between the frame member and the drop arm to free the drag link. In such cases the drop arm should be moved outwards, after slackening the pinch bolt, just enough to give the necessary clearance. It is not necessary to remove the drop arm altogether, and in fact this should be avoided whenever possible, as the presence of the wing may make refitting difficult. The other point is that flexible brake pipes should be disconnected by unscrewing the adapters, and not by attempting to twist the pipes themselves.

Bleeding of the brake system will, of course, be necessary after reassembling.

Front-axle Dimensions

The following front-axle dimensions are applicable to all models from 1934 onwards, and may be useful:

Camber angle $1\frac{1}{2}°$. Castor angle 3°. Toe-in $\frac{1}{8}$ in. to $\frac{3}{16}$ in.

The king-pin inclination of 1934 and 1935 models is $7\frac{1}{2}°$. This dimension applies also to the early Dolomite, Vitesse, and late Gloria models, but it was altered to $8\frac{1}{2}°$ for the 1938 season and onwards. It should, therefore, be noted that the angle of the pivot-pin holes of a Dolomite-, Vitesse-, or Gloria-type axle beam obtained from the makers will be $8\frac{1}{2}°$ irrespective of what the original may be, except for early Gloria models, which remain unaltered.

It may be noted that all front-axle beams are machined on one side for the cotter-pin nuts, and this side of the axle must face the front.

Spring-shackle Rattle

The development of spring-shackle rattle is usually curable by the fitting of hardened shims, which can be obtained from the manufacturers.

Prior to 1938, a plain phosphor-bronze bush was fitted in the spring eyes, and in cases where rattle is found to be caused by movement of the spring on the bush, the fitting of shims, the internal diameter of which corresponds to the outside diameter of the bush, is recommended. If the bush itself moves sideways on the pin, shims having an inside diameter similar to that of the pin should be used.

Two flanged half-bushes are fitted to the springs of models manufactured since 1937, and with this type shims can, of course, be fitted under the bush flange if the side movement is excessive. Should this movement be allowed to develop sufficiently to allow the links to become damaged, the faces of the spring eyes, of models prior to 1938, should be ground, and the inside link faces filed smooth, otherwise new shims will quickly be destroyed. The latter portion of this recommendation is applicable also to cars fitted with half-bushes.

If the pins themselves are worn, they must, of course, be renewed when the assemblies are being overhauled.

Some cases of spring-bracket rivets working loose have been experi-

enced, and the simplest and most effective remedy is to remove the rivets, enlarge the bracket and chassis frame holes to $\frac{3}{8}$ in. and fit bolts and nuts and locknuts in place of the rivets.

Removing Bodies

All Triumph bodies are hand panelled in aluminium, with the exception that in most cases a steel scuttle panel is fitted.

The following notes on removal and refitting of bodies are intended for the most recent productions, these being a little more complicated so far as details are concerned than the Gloria and other early types. The general procedure is the same for the whole Triumph range back to 1934.

Slide the seats from the runners and remove the runners from the floorboards to which they are screwed. Take out the rear seat, squab, etc.

Lift the front portion of the carpet and pull it free of the control pedals, and of the metal strips running along each side of the car floor. Here it may be noted that the organ-type accelerator control fitted to some models hinges on a bracket bolted to the toe-board. The hinge pin is held by a setscrew which will be found at the base of the pedal. Take off the gear-control gaiter, and then remove the floorboards and the rear foot well, all of which are screwed in position. Note that the control-pedal lever pads must be taken off before it is possible to remove the toe-board. Take off the metal propeller-shaft tunnel.

Remove the petrol-tank filler, leaving the rubber hose attached to the tank, and take up the floor of the luggage compartment.

Pull the pedal-box carpets away and take away the glove tray, pedal-box casings, etc., noting that it is necessary to disconnect the steering column at the pedal-box anchorage, and to lower it, also to remove the pistol-grip-type hand-brake control of current models.

Open the windscreen and take out the screen capping screws, take off the central screen-winder handle, and remove the instrument-panel attachment screws (including the steady-bracket screws if brackets are fitted), and carefully lower the panel complete.

Take out the two bolts and several screws attaching the chassis scuttle dash to the body scuttle extension.

Remove the eight coach bolts holding the body to the frame, three at each side and two at the rear. Take out the four coach bolts attaching the front wings to the pedal box, and the screws holding the running boards to the body. Remove the bolts passing through the rear wings and the rear ends of the running boards. Note that the rear wings may be left attached to the body and that it is not essential to remove the front wings either, although this is advisable. Notes on wing removal are given later.

Disconnect the roof light or lights at the switch end of the wires, and the traffic-indicator wires at the special joints which will be exposed in the vicinity of the body centre pillars, at the bottom, when the floorboards

are removed. Disconnect also the tail-lamp wires and the screen-wiper wires.

Remove the rear bumper complete with its brackets.

Lift off the body, taking care not to damage the covering of the steering wheel while doing so. Tie up the instrument panel to the pedal box, to prevent damage while the body is off.

Remounting Body

Having ensured that the body mounting felt strips are in position, place the body on the chassis, and after lining it up, fix the dash to the scuttle.

It is a generally accepted principle to work from the front end when mounting a body ; therefore, attention should first be given to the front doors. These will need raising, assuming that they require any attention at all, and the object is to obtain an all-round gap or clearance of about $\frac{1}{8}$ in. A trial-by-error method has to be adopted, but, broadly speaking, any raising is done by inserting packing of suitable thickness between the body and chassis frame at the nearest mounting point—in this case the points opposite the body centre pillars. When the front doors hang correctly, both front and centre mounting bolts may be finally tightened down.

Repeat the procedure with the rear doors, and when these are correct, the remainder of the mounting bolts may be tightened, care being taken to ensure that the rear of the body is not pulled down when the bolts passing through to the rear-frame member are tightened. Packing-pieces, used as described above, will, of course, obviate this.

The doors usually need further slight adjustment after road test, and this is done by packing the hinges as found necessary.

The front wings may now be fitted, working, as before, from the front end, i.e. attaching the wing stays first of all. The rear wings should be attached to the body before it is mounted.

REMOVAL OF WINGS

1934 Gloria Models

Disconnect the head- and side-lamp wires. Loosen the headlamp standard pinch bolt, and pull the lamp and standard out. Remove the sidelamp attachment nut from the underside of the wing, which will release the lamp.

Loosen the front cowl by taking out the three fender bolts, take off the front bumper, if one is fitted, and the front number plate.

Remove the two front and one rear-wing stay bolts and the three fender bolts passing through the wing flange and the bonnet board.

The wing of this model is separate from the running board, and if it is desired to remove only the wing, it is now only necessary to remove the

tread-strip stud nuts which pass through the wing, and the fender bolts attaching the wing to the running board.

To take off the running board also, remove the fender bolts which pass through the step irons, the body screws which hold the board to the underside of the body, and the fender bolts at the rear end.

The rear wing is easy to remove, as it is held by six coach bolts, and possibly one or two wood screws. The coach bolts are inserted through the wheel arch from the inside of the body, and before the upholstering is carried out, so that every care should be taken to avoid breaking these when removing the nuts. Use penetrating oil or paraffin if the nuts are very tight. (It may be noted that these instructions apply to all models.)

1935 Models

Remove those lamp stay bolts which pass through the wing, and so far as the head- and side-lamps are concerned, proceed as before, noting in this case, however, that it is not essential to remove the headlamps.

The front shock absorber must be loosened, however, as the wing is held between it and the chassis frame and, in addition, the top front-spring link pin must be removed.

Take out the bolts passing through the wing flange, bonnet board, and chassis frame.

A combined wing and running board is fitted to this model, and the heads of the step-iron bolts are concealed by the running-board tread strips. Two bolts attach the running board to the rear wing.

As will be seen, the moulded rubber tread strips are held by aluminium holders which are bolted through the running boards. The insertion of a screwdriver between the strip and the holder is all that is required to loosen the former, after which it may be pulled out of its holder. The easiest way to refit these strips is to insert the whole of one side and press in the other side, bit by bit, with the aid of a screwdriver or similar tool.

1936 Models

Remove the headlamp brackets and proceed as before. Note in this case that the wing stay and chassis wing stay are bolted together, and that, as previously, one spring link pin must be removed.

The wing is separate from the running board, and the two parts are bolted together with five bolts which also pass through the flange of the chromium-plated moulding fitted to conceal the joint.

The running board is attached to the step irons by means of bolts passing through the latter and through L-shaped pieces welded to the board.

1937 and Later Models

The instructions given above apply also to subsequent models, though there are one or two additional points to note. The Dolomite type

of front wing has an extra stay, which will be found below the pedal box, and which is attached to the chassis stay in a manner similar to that described for the 1936 models.

Four bolts pass through the wing flange and riser iron, and the bolts which fasten the front portion of the wing to the side section of the radiator grille must be removed.

Removal of these wings is simplified if the front-bumper studs are taken out.

Rear wings are fitted with splash guards welded to the wings and screwed to the body structure.

Removing Sliding Roof Panels

Sliding roof panels are easily removed, the method of procedure being as follows:

Remove the headlining covered fillet, after taking off the locking handle which is attached by a centre screw. Removal of the fillet exposes the roof lock attachment screws, and when these have been taken out, the panel can be pulled off the runners, over the canopy panel.

The fillet is attached by "invisible" pins.

Water leaks through Windows

A leakage of water via the rear windows indicates the necessity of rebedding these glasses, and after removing the screwed cappings, a thin knife-blade inserted between the bedding rubber and glass is all that is necessary to release the windows, which are, of course, fitted from inside the body.

A bedding compound should be applied generously to the rubbers and the glasses pressed back in position. Surplus bedding compound, squeezed out between rubber and glass, should be wiped off after the refitting of the windows is completed.

A good bedding compound, in addition to being waterproof, will retain a certain amount of resilience, which is a desirable feature.

The moulded rubber window surrounds are attached by means of tacks.

Curing Door Rattles

A general tightening up of hinges, etc., and possibly the fitting of new rubber buffers, will cure door rattles where recent productions are concerned, but the earlier Gloria models have metal wedges screwed to the door frames above and below the doors. Corresponding wedges are fastened to the doors themselves, the top ones being a spring-loaded type. If it is found possible to slide a cigarette card or something of the sort between the top wedges, the fixed wedge on the top of the door frame should be removed, and refitted with suitable packing behind it.

Door Casings and Window Winders

To obtain access to the window-lifting mechanisms, the winder handles and the door casings must first be removed.

The 1934 Gloria type of winder handle is held on its shaft by a spring, and to remove it, a stiff wire, such as a wheel spoke, should be inserted in the hole which will be seen in the flange. Pressure on the end of the spoke will release the spring, and at the same time the handle can be pulled free.

Later-type handles are pegged to the shafts, and to remove these the spring-loaded cover must be pulled back, which action will expose the peg. The driving out of the peg will release the handle.

The " quick-lift " types fitted to Roadster and Royal models have screwed-on handles.

Removal of the door casings of the earlier models requires no explanation, as these are simply screwed to the door structure, but the casings of the more recent productions are attached by means of blocks, and to release these it is necessary to take out the screws which will be found in the door edges.

The chromium-plated door and scuttle mouldings slide over screws fixed in the panels, and may be tapped on and off in a horizontal direction. Bonnet and quarter mouldings are bolted through the respective panels, and in the case of the latter some of the interior trimming must be removed to obtain access to the bolts.

THE A.E.C. CHASSIS

REAR AXLES

THE following notes refer to A.E.C. rear axles, which are all of the fully floating type. Three types of drive are employed :

(*a*) Overhead worm drive.

(*b*) Underslung worm drive.

(*c*) The double-reduction type.

The first part of the article deals with the drives (*a*) and (*b*). Axles of all types have the brake drums mounted on the outside of the hubs so that the brake shoes can be inspected and relined without disturbing the wheel bearings or removing the hubs.

The hubs are mounted on two large-diameter roller bearings, the outer one of which is arranged to take end thrust.

The hub bearings are lubricated with grease, and provision is made to keep the lubricant from the brake shoes by means of a packless gland in conjunction with a felt washer. This gland is shown in Fig. 1, and takes the form of a bronze ring held against the outer rod of the roller bearing by means of a spring.

To remove the Axle from the Chassis

Disconnect the rear cardan-shaft coupling flange, and the brake rods. Remove the wheels, remove the clamping bolts from the inner ends of

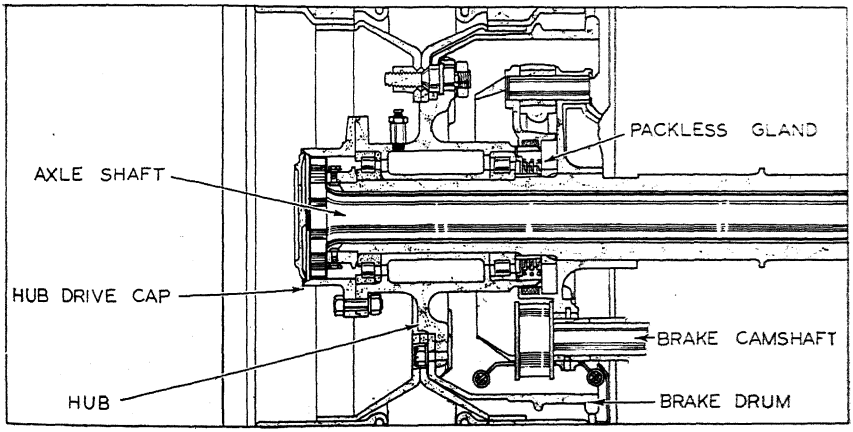


Fig. 1.—SECTION OF REAR AXLE SHAFT AND HUB

the shackle pins, and drive out the pins. Drop the axle on to the ground, jack up the frame until high enough to allow the axle to be drawn out towards the nearside. If available, one of those flat trolleys with only a few inches of overall height will greatly assist in moving out the axle. A piece of board will prevent the nuts on the spring bolts from digging into the ground.

The propeller shaft must not be allowed to hang loose. Wire the shaft up to a convenient cross-member.

To withdraw Axle Shafts

Remove the hub caps and withdraw the axle shaft from the casing.

To remove Brake Drums

Remove the wheels and the slotted nuts securing the brake drum to the hub. Insert two $\frac{1}{2}$-in. B.S.F. setscrews into the withdrawal holes in the brake drums and remove the drum.

To remove Hubs

Remove the wheels, hub cap, and driving shaft. Remove the two locking bolts on the axle-tube nut after first marking the nut and casing to ensure that, when replacing, the nut is tightened up to the same mark. Unscrew the nut and withdraw the hub complete with bearings, distance-piece, and brake drum. The packless gland will be left on the axle tube and can now be removed ; the felt washer will be left exposed in the brake-carrier plate.

Great care should be taken in handling the packless gland so that the rubbing face is in no way damaged. When replacing the hub, the rubbing face of the gland should be smeared with grease to effect lubrication until the oil has a chance to reach this face.

To remove Worm Carrier

Remove the hub caps and axle shafts. Disconnect the rear coupling flange and wire up the propeller shaft to a convenient cross-member. Remove the nuts holding the worm carrier to the axle, screw into the tapped holes in the flange of the worm carrier the four $\frac{1}{2}$-in. B.S.F. set-screws provided in the tool-kit, and force the carrier out of the register in the axle by screwing the four screws up evenly.

Care must be taken that the worm carrier does not fall to the ground.

To adjust the Differential Roller Bearing

The roller bearings carrying the differential are adjusted in the case of the overhead worm drive by means of two slotted nuts which embrace the ends of the bearing cups, or, in the case of the underslung worm drive, by means of shims placed between the bearing and the casing. To obtain the correct adjustment, the two nuts should be screwed up carefully until

the bearings are just nipped, and the nuts then backed off just enough to free the bearings. An end play of not more than ·004 in. should be allowed.

Running adjustment should always be made on the offside bearing, as any slack which has developed will be in this bearing.

For adjusting the bearings when reassembling after stripping the worm carrier, see "Adjusting the Wormwheel."

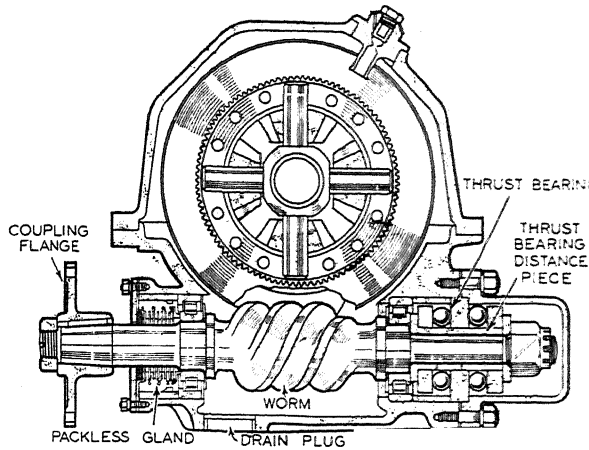


Fig. 2.—UNDERSLUNG REAR AXLE WORM DRIVE

To remove Wormwheel and Differential

Remove the two bearing caps, and lift out the wheel and differential complete.

When replacing the wormwheel, in order that the thrust shall not come on the bolts, the flanged side of the wheel must face towards the near side of the chassis.

To remove Worm

Remove the wormwheel as given previously.

Remove the domed cover from over the thrust bearing, mark the slot in which the split-pin rests, unscrew the nut securing the thrust bearing, and thread the bearing off.

After removing the nuts securing the gland to the front of the housing, the worm may be withdrawn with the forward roller bearing and the gland box in position on the shaft. In the case of the underslung worm drive, a packless gland, similar to that fitted in the hubs, is fitted to the worm shaft.

Except to replace or change the worm, to renew the forward roller bearing, or repack the gland, the Spicer coupling flange should never be disturbed.

It is important that the thrust-race and its distance piece be kept together. If the thrust bearing is renewed, the packing piece must be renewed also. The length of the packing piece must be exact, so as to give the correct amount of end play to the worm. Packing pieces are selected at the factory to the correct length to give an end play of

·006–·008 in. When replacing the nut make certain of the clearance. Over-tightening the nut will compress the distance piece.

To dismantle the Differential

Unless it is absolutely necessary, do not disturb the differential. Otherwise, proceed as follows :

Mark the wheel and differential casing so that the same mesh of the tooth drive can be picked up when reassembling.

The tooth drive between the differential and the wormwheel is made a tight fit, and a considerable amount of pressure will be required to separate them. After removing the bolts, the assembly should be placed on a press with the toothed side downwards. Pack up the wormwheel until the differential casing is about $1\frac{1}{2}$ in. clear of the table and, after placing a piece of soft metal over the upper end of the differential housing, force the housing out of the wormwheel.

The bushes for the differential bevel wheels are made a free floating fit to equalise the drive to all four pinions. The correct clearance, between both the bush and the casing and the bush and the bevel, is ·008 in.

Should a press be not available, a large drawing dog or " Jim Crow " bender can be adapted to the purpose. Great care must, however, be taken to avoid damage to the wormwheel teeth.

If a heavy hammer is used, the greatest care must be taken ; to keep on hammering with a hammer which is not heavy enough to produce any effect will only result in damage to the end of the differential casing.

For reassembling, a press should be employed or, failing this, some bolts procured which are about an inch longer than the bolts used for holding the wormwheel and differential casing together. The casing can then be drawn into the wheel by using a long spanner and working from one bolt to the one opposite until the casing is home. The nuts must be hammered up hard and must on no account be slackened off to enable the split-pin to be entered.

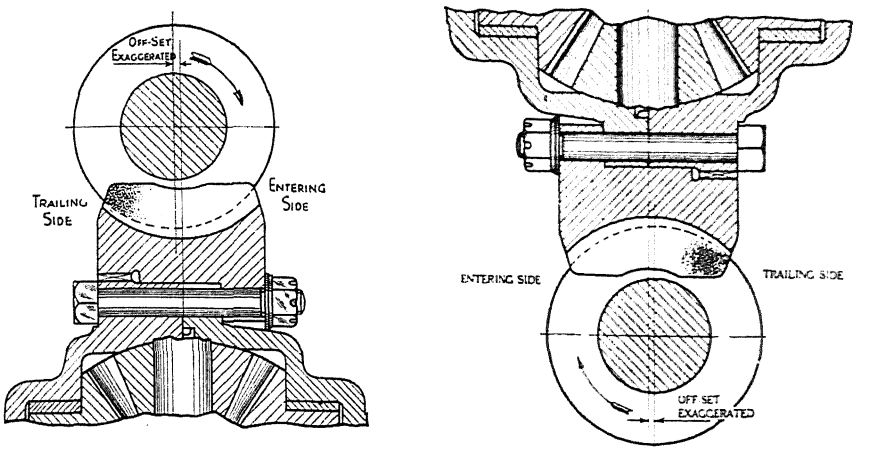
To adjust Wormwheel

Wipe all the oil from inside the worm carrier and give the worm a light coating of blue marking.

Place the wormwheel and differential in position, and replace the caps with the nuts just tightened enough to hold the bearing cups snugly on to their seats.

Dealing with the overhead type of worm drive, by means of the adjusting nuts, bring the worm as central as possible, and, after adjusting the bearings until all the slack is out of them, slack off each nut one slot.

Turn the driving flange of the worm in a clockwise direction and, at the same time, apply a load to the wheel in order to obtain a good marking of the bed on the wheel teeth.



Overhead drive

Underslung drive

Fig. 3.—SETTING OF WORM AND WORMWHEEL

In order to obtain maximum efficiency from worms and wheels, the initial setting of the wheel should be such that the assembly marking (red lead or Prussian blue) is more pronounced on the trailing side of the wheel teeth (as shown shaded) than on the entering side.

Adjust the wormwheel to right or left as required (being careful to turn each nut an equal amount in the same direction), until a marking is obtained which covers from one-half to three-quarters of the width of the tooth, and is *mainly on the leaving side* of the tooth and upon the driving face of the teeth. When running under load, the wheel will be forced over slightly, and the marking will shift towards the entering side of the wheel.

For adjusting the underslung type of drive, shim up until the required marking, as described above, is obtained.

DOUBLE-REDUCTION-TYPE REAR AXLE

In the double-reduction-type driving axle, the first reduction is by a spiral bevel assembly, the second reduction by a double helical pinion and wheel. The axle is fully floating, the hubs being mounted on roller bearings mounted on the one-piece axle pot.

In addition to the foregoing instructions for the withdrawal of axle shafts, and the removal of brake drums and hubs (and exclusive, of course, of those instructions relating to the removal and dismantling of the worm carrier, etc.), the following directions apply to A.E.C. double-reduction-type rear axles.

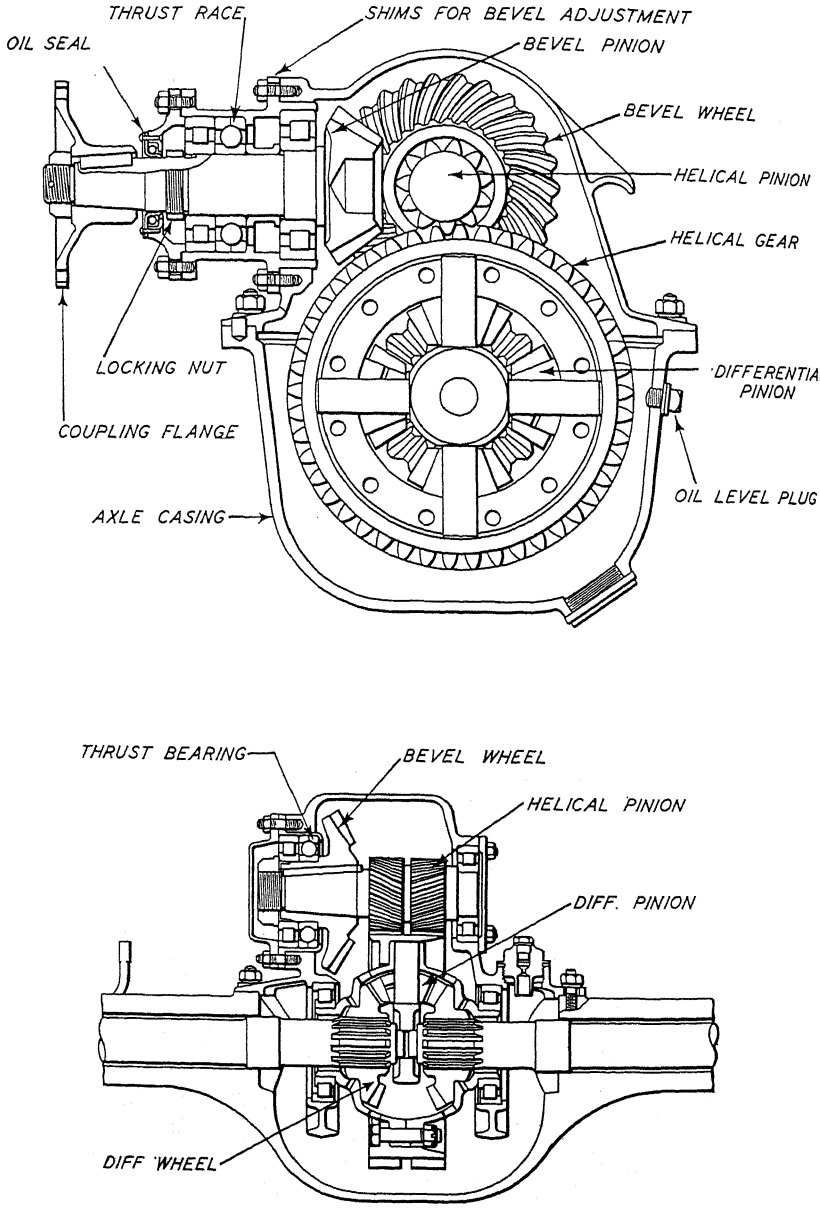


Fig. 4.—DOUBLE REDUCTION DRIVING AXLE

To remove Bevel Casing

The bevel casing can be removed without removing the axle from the chassis.

Remove the hub caps and axle shafts. Disconnect the rear propeller shaft flange. Remove the nuts holding the worm carrier to the axle, screw into the tapped holes in the flange of the housing the four $\frac{1}{2}$-in. B.S.F. setscrews provided in the tool-kit, and force the carrier out of the register in the axle by screwing the four setscrews up evenly.

To remove Double Helical Gear and Differential

Remove the two bearing caps, and lift out the wheel and differential complete.

To remove Bevel Pinion

Remove the nuts from round the flange securing the bearing housing to the reduction casing, and withdraw bevel pinion complete with bearings, housing, and coupling flange from the reduction casing.

To remove Bevel Wheel and Helical Pinion

Remove both the covers from the sides of the reduction casing and unscrew the nut which locks up the roller and thrust bearings, and remove the housing complete with bearings.

In order to remove the helical pinion and shaft, the bevel wheel must first be removed from the shaft. This bevel wheel is mounted on a long taper and the hub of the bevel wheel is screwed so that a withdrawal tool, supplied in the tool-kit, can be screwed on to the wheel.

The only reason for the removal of the wheel from the shaft is when replacement of either of these parts becomes necessary.

To adjust Mesh of Bevel Wheels

Shims are fitted under the housing for the bevel-pinion bearings, and also under the housing carrying the helical gear bearings. Adjustment should be such that the bevel pinion can be freely rotated without any hard spots, and with from ·002 to ·004-in. backlash in the gears. The gears should be so adjusted that contact is made across the whole length of the tooth.

To dismantle the Differential

Unless this is absolutely necessary, do not disturb the differential.

Mark the helical wheel and the two halves of the differential casing so that they may be reassembled correctly.

After removing the bolts, the helical wheel should be pressed off the casing and the casing divided.

FRONT AXLES

The axle beam, steering swivels, and hubs are all of heavy-design forged alloy steel.

The swivels have plain bearings, a roller thrust washer being fitted to take the thrust load. The thrust washer has a spherical seating to ensure uniformity of distribution of the load, and is encased in a pressed steel housing to exclude mud and water. The upper and lower ends of the king-pins are made oil- and water-tight by felt washers.

Two large tapered roller bearings carry the wheel load. The adjusting nut is split, and fitted with a clamping bolt to ensure that it is a tight fit on the thread, and is locked by a setscrew which engages in one of a row of holes drilled in a heavy washer keyed to the stub axle. The nut on the nearside has a left-hand thread, and that on the offside a right-hand thread.

To retain the grease in the hub the usual felt packing is fitted.

To exclude grease from the brakes, a light pressed cylinder is attached to the brake carrier and embraces the inner end of the hub. Attached to the hub is a conical sleeve which overlaps the cylinder on the brake carrier, so that any grease which escapes from the hub will be passed by the cylinder into the cone from which it escapes through holes in the hub to the outside of the wheel, and is thus kept away from the brakes. The appearance of grease at the openings in the hub serves as an indication that either too much grease is being fed into the hub or that the felt needs replacing.

The swivels are fitted with an adjustable stop to limit the travel. These are adjusted correctly at the factory and should need no further adjustment unless larger tyres are fitted at any time.

Maintenance

The front hubs must be kept full of grease. If the hub is not filled right up, the grease will not reach the thrust end of the inner bearing, which will consequently wear on the ends of the rollers. Adding a small amount of grease to a bearing which is not full will only displace some of the air and will not force the grease to all parts of the bearing.

The spring bolts must be kept screwed up hard and checked every 5,000 miles. The king-pin must be lubricated with oil.

Every 5,000 miles check the bearing adjustment, and readjustment if more than a just perceptible amount of shake can be felt.

At the same time the alignment of the wheels must be checked. The front wheels must be kept between parallel and $\frac{1}{8}$-in. toe-in, and must be adjusted at once if found to be otherwise. The ends of the track rod are screwed right- and left-hand to facilitate adjustment.

To remove the Axle as a Unit

Jack up the frame to take the weight off the springs. Disconnect the Lockheed-brake flexible pipe, shock-absorber links, and the drag link.

The latter is done by removing the nut which holds the ball stud to the steering arm, and driving out the ball stud.

Remove the clamping bolts holding the springs to the axle and roll the axle from beneath the chassis.

To remove the Hubs

Remove the wheel and hub cap, take out the locking screw, slack off the clamping screw, unscrew the nut, and pull off the hub. The inner races are a push fit on the stub axles, and that of the inner bearing will probably remain on the axle, but the outer bearing will come away complete with the hub.

The axle must not be allowed to rest on the dust shields, but must be packed up so that the shields are clear of the ground.

If the felt washer requires renewal, the bearings must be adjusted before the washer is placed in position. After adjusting the bearings, the nut and the lock washer must be marked. The hub must then be removed and the new washer fitted, and, after replacing the hub, the nut must be brought up again to the same position with the lockscrew in the same hole of the lock washer.

Unless this precaution is adopted it is difficult to be sure of the adjustment, as the compression of the felt washer makes it difficult to check the amount of slack in the bearings.

After replacing the wheel, always check the bearings for slack: the greater leverage given by the wheel makes it easier to feel any clearance. The bearings must be adjusted to give a just perceptible amount of shake when throwing the whole weight of the body on the wheel.

The hubs must not be interchanged, as the wheel studs are right-hand on the offside and left-hand on the nearside.

To remove the Swivels

Remove the wheel and hub. Remove the front-wheel piston, etc., as described later under "Brakes"; also remove the bleeder screw and adapter from the top of the king-pin.

Slacken off the nut at the top end of the king-pin until the surface of the nut is somewhat above that of the end of the pin, and free the pin from the axle with a sharp blow from a heavy *soft* hammer.

The king-pin should be a good fit in the bushes, but should also be quite free. Should the clearance exceed ·03 in., the bushes should be replaced.

The swivel should be free, without end play. This is governed by the plain washer fitted on the top of the axle boss, this washer being selected to be a push-fit into the space between the axle and the swivel. This washer, however, takes no load, as all the thrust comes on to the roller washer beneath the axle boss.

The pressed steel housing to the roller washer must be free in the

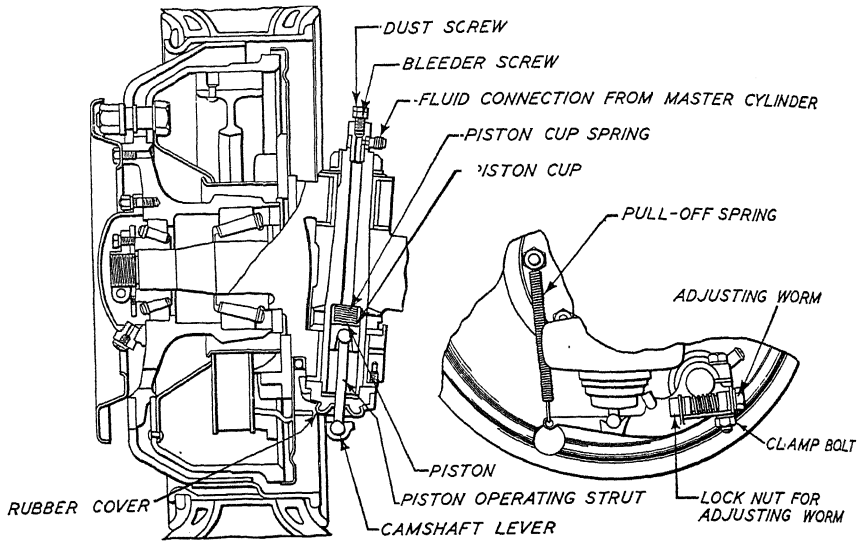


Fig. 5.—ARRANGEMENT OF FRONT AXLE AND FRONT BRAKE CYLINDER

recess in the swivel, and should remain stationary when the swivel is moved. While the swivel is dismantled the roller washer and its recess should be thoroughly washed out to remove any grit or rust which may have accumulated. A thrust washer which shows any signs of wear or indentation should never be used again. When replacing the washer it should be well packed with grease.

If, for any reason whatever, the Lockheed pipes are disconnected, the whole system must be bled. It is important, too, that before the wheel piston and cups are reassembled, they be thoroughly cleaned with Lockheed Orange-fluid.

BRAKES

The foot-brake operates on all wheels and is actuated by a servo-assisted Lockheed hydraulic system. The hand-brake operates on the rear wheels, and actuates the same set of shoes as used for the foot-brake.

The brake drums are 17 in. in diameter, and the shoes are 6 in. wide on the rear and $3\frac{1}{4}$ in. wide on the front. All the brake shoes are fitted with $\frac{3}{4}$-in. thick liners, and provision is made for packing-plates to be inserted between the cam and the rubbing-plate so that the liners may be worn down to the minimum thickness before relining. The application of these rubbing-plates is shown in Fig. 8.

Various arrangements of brake gear are shown in Figs. 6, 7, and 9.

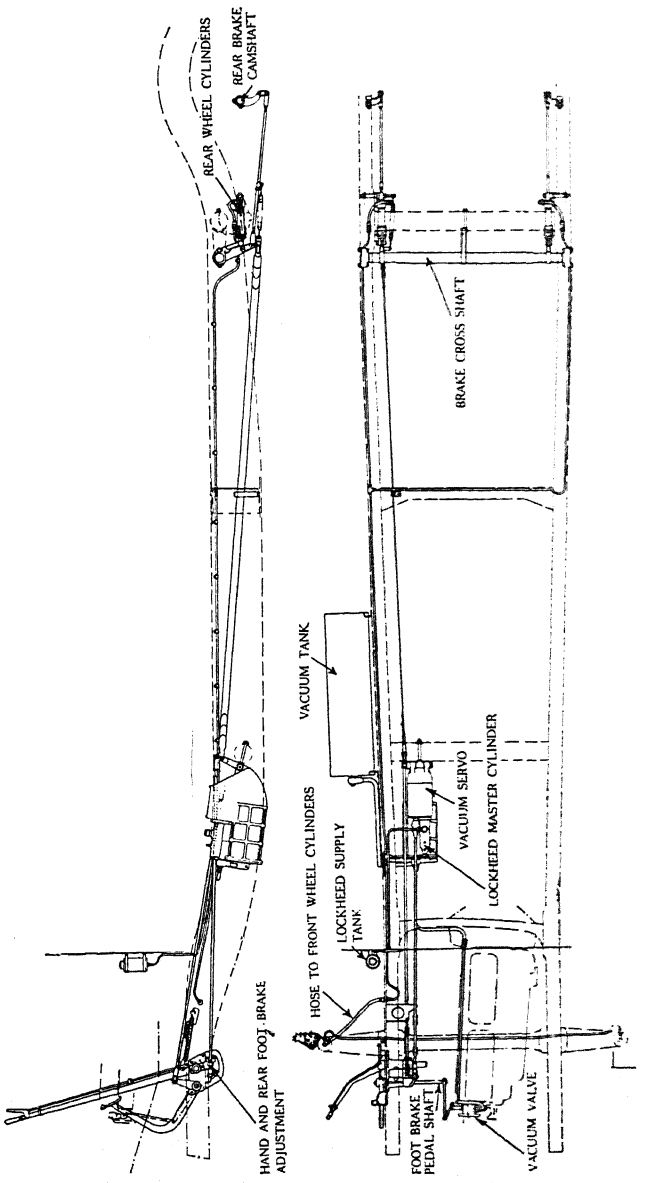


Fig. 6.—BRAKE LAYOUT
Showing combined Lockheed master cylinder and vacuum servo.

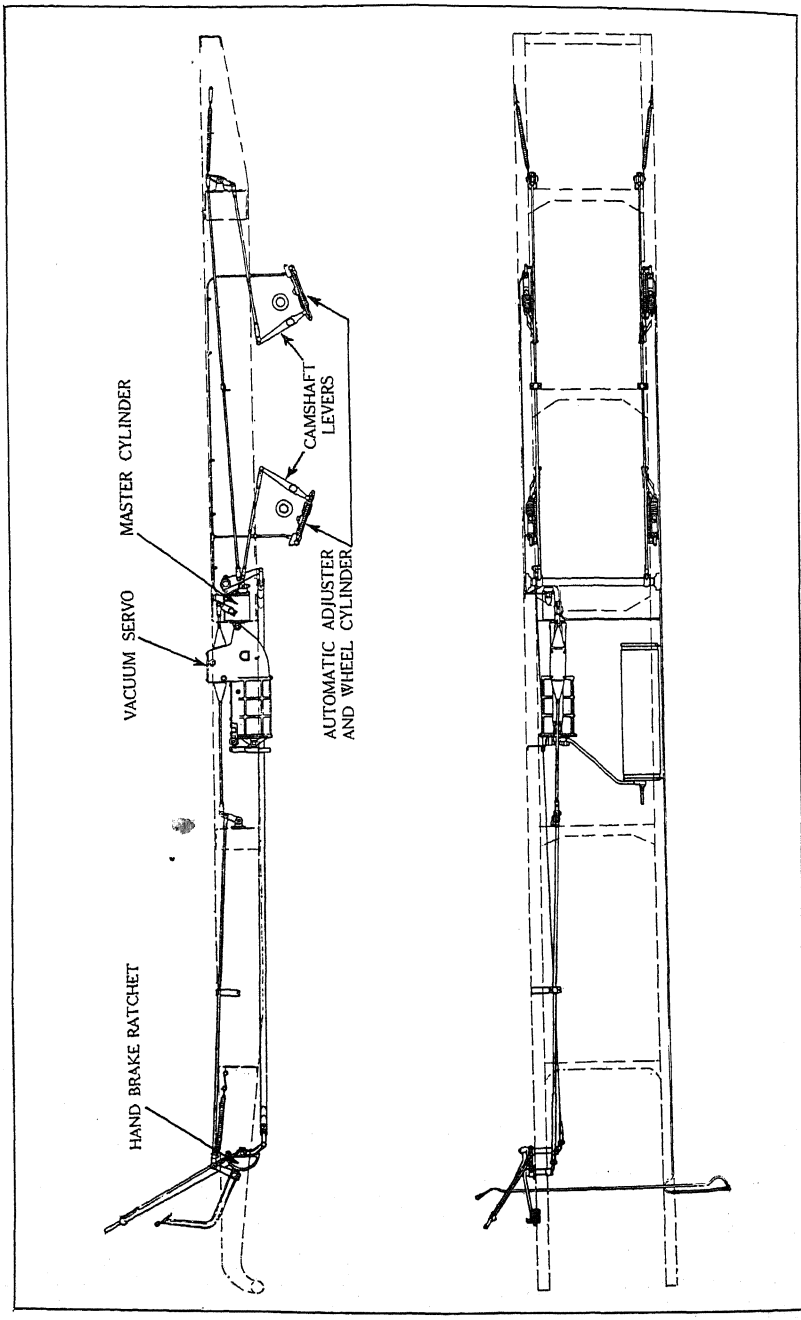


Fig. 7.—SIX-WHEELER BRAKE LAYOUT
Note the automatic brake adjusters for the rear four wheels.

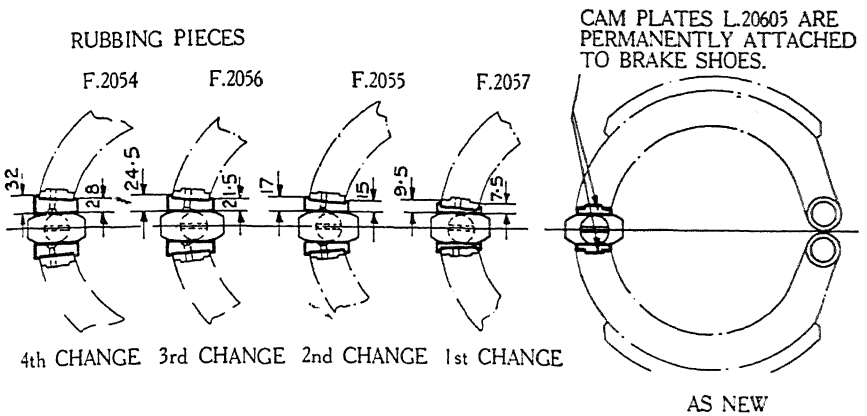


Fig. 8.—FITTING BRAKE-SHOE RUBBING PLATES

Note.—An additional rubbing piece should be fitted when the angularity of the cam, as determined by line machined on end of camshafts, is from 40° to 45°. F.2055 being usually suitable, F.2057 to be used if it is desired to pack brakes before an angle of 40°–45° is reached. To fit additional rubbing piece, force shoes apart and insert piece required. Additional pieces are retained by peg locating in standard cam plate.

Front-wheel Cylinders

The front-axle king-pins are bored out at their bottom ends and form the cylinders in which the pistons work, the actuating fluid being admitted at the top of the king-pin (*see* Fig. 5).

Fluid pressure is transmitted through the piston to a short ball-ended strut, the lower end of which rests in a cavity in the cam lever. Round the lower end of the cylinder a rubber boot is fitted which prevents dust and water from affecting the working parts.

Brake Adjustment

The length of the brake rod between the servo and the master cylinder is set at the factory, and should on no account be altered. Shortening of this rod will result in binding brakes.

Rear Brakes

The rear brakes on some chassis are adjusted by means of the adjusting nuts on the rear-brake camshaft levers. As it is obviously impossible to provide sufficient adjustment to completely wear out the extremely thick liners fitted on the brake shoes, it is necessary to insert packing between the brake shoes and the camshaft when the rear-camshaft levers come too far over centre. The procedure to be adopted when this is necessary is explained in Fig. 8.

Automatic Adjusters

In other chassis, the rear-brake adjustment is automatic. There are two types of automatic adjuster used in A.E.C. chassis.

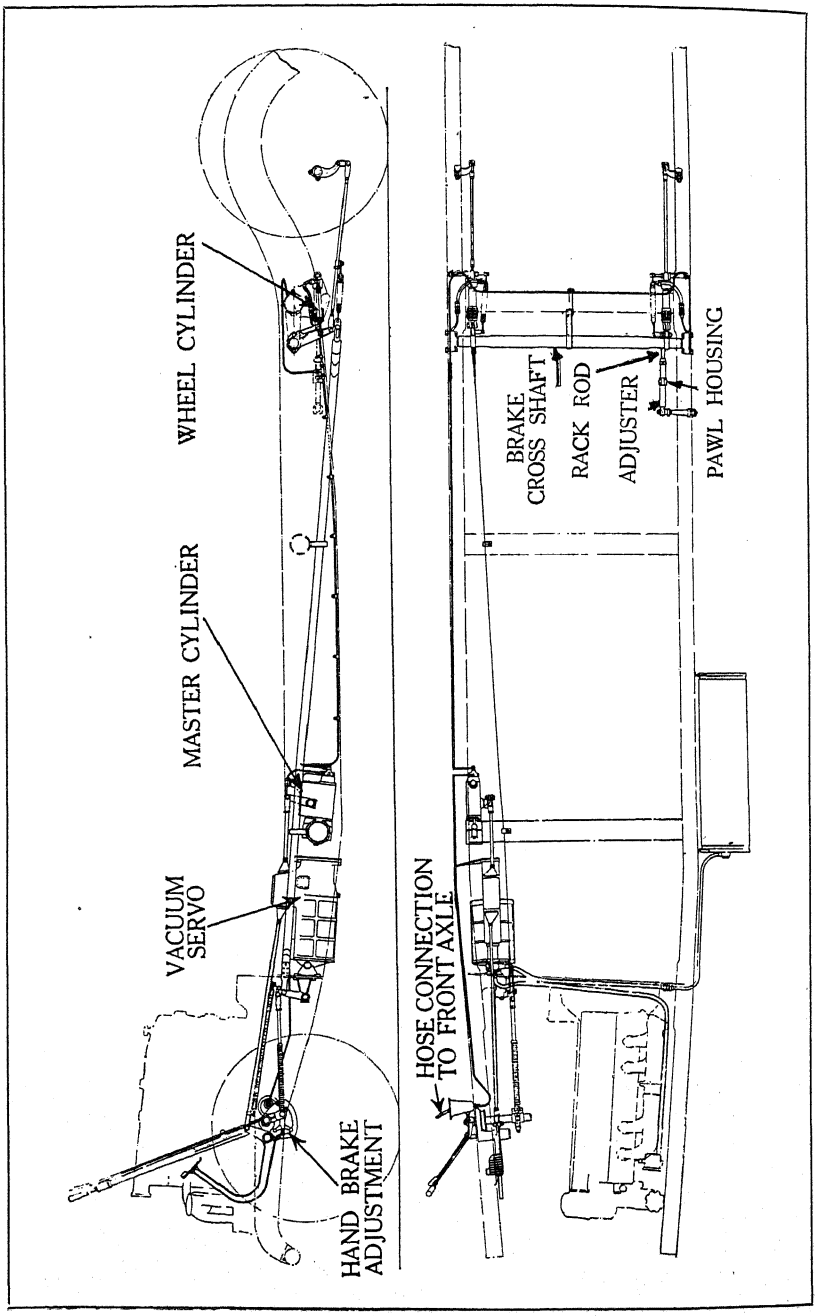


Fig. 9.—BRAKE LAYOUT
Showing another type of automatic adjuster for the rear brakes.

In the first type the automatic adjustment is provided for in the wheel cylinders. When all the movement provided in the wheel cylinder is used, it is necessary to pack out the shoes.

This should be done when the dimensions between the eye of the cylinder anchorage and the eye of the piston approaches 373 mm., which is the length when fully extended. After packing out the shoes, it is, of course, necessary to disconnect the piston from the camshaft lever and to push back the piston to its original position at the beginning of its stroke. Always make quite certain before reconnecting the piston and the camshaft lever that the spring-loaded ratchet pawl is in engagement with the teeth on the piston.

The second type of automatic adjustment is arranged as shown in Fig. 9. Attached to the centre of the swing lever is a rack-rod having a series of buttress teeth cut on it, these teeth engaging with a spring-loaded pawl having teeth of similar form. The pawl is held in a casing mounted on tubular member which acts as a guide for the rack-rod. The further extremity of the tubular member is slotted and is attached to a fixed pin anchored on the frame. Thus the brake rod and the adjuster gear are free to float laterally by the length of the slot, which provides a minimum initial clearance for the brake shoes. As brake wear takes place the movement of the brake rod will exceed that provided by the slotted hole, and the rack teeth will commence to override the pawl, until, as wear proceeds, the pawl will seat again in the next series of teeth, the original shoe clearance then being restored. Dirt and water are prevented from injuring the working parts by the provision of the gland nut and felt packing.

Two grooves are cut on the rack-rod and serve as an indication of the amount of adjustment that has been used in the automatic adjuster. When the groove nearest the fork end comes in line with the face of the gland nut, the amount of adjustment provided by the automatic adjuster is taken up, and it is necessary to insert, between the cam face and the brake shoe rubbing-pieces, the packing-pieces provided for this purpose. When this is done the adjuster mechanism must be reset to its original position with the rear cylinders fully compressed. To do this, remove the bolt from the slotted end of the adjuster, and turn the outer casing half a turn in either direction. This will disengage the pawl from the rack and enable the adjuster to be extended. Having been extended, the pawl must be re-engaged in the rack by returning the adjuster casing, care being taken that this is returned in the correct direction.

Front-brake Adjustment

Front-brake adjustment is provided for in the following manner:

The boss of the cam lever carries a worm engaging with suitable teeth cut in the brake camshaft. To adjust the brakes, the clamping bolt and the locknut on the end of the adjusting worm are first slackened off, and

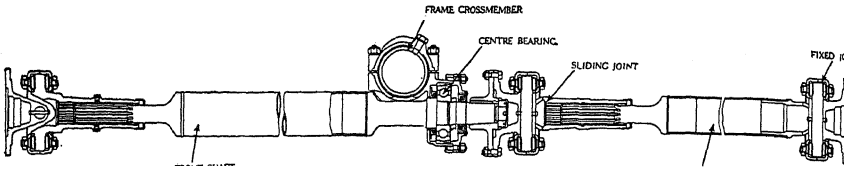


Fig. 10.—ARRANGEMENT OF PROPELLER SHAFT (WITH SPICER JOINTS)

then the worm is rotated, causing the brake camshaft to turn in relation to the cam lever and bringing the shoes nearer to the drum. When the brakes are adjusted, tighten clamping bolt and lock worm by means of the locknut.

When the front brakes are properly adjusted, there should not be more than 15 mm. of travel on the piston push-rod (*see* Fig. 5). This point should be checked periodically by getting someone to apply the brake whilst the movement is observed. Should the movement approach 30 mm., then the front brakes should be immediately adjusted as outlined above.

After a certain amount of adjustment has been taken up it will be necessary to insert packing-pieces as on the rear shoes. This is necessary when the notch cut on the face of the brake lever comes in line with the notch on the end of the brake camshaft.

PROPELLER SHAFT

A.E.C. tubular propeller shafts are made in two sections, and supported at the centre by an intermediate bearing mounted on one of the frame cross-members.

Three couplings are used, one immediately behind the gearbox, one immediately in front of the rear axle, and the third to the forward end of the rear half of the propeller shaft.

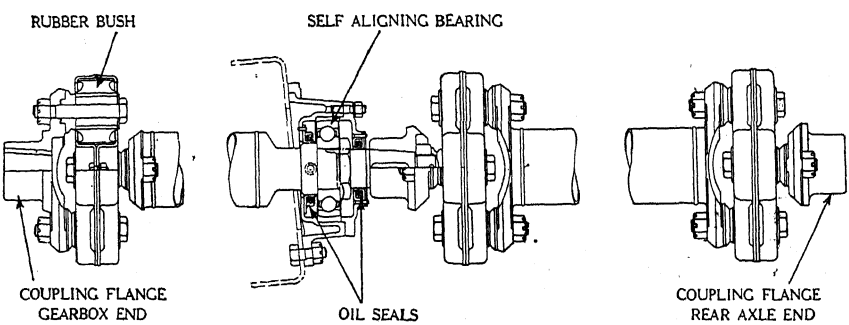


Fig. 11.—ARRANGEMENT OF FRONT AND REAR CARDAN SHAFTS (LAYRUB UNIVERSAL JOINTS)

The intermediate bearing, which is fitted to the rear end of the forward half of the propeller shaft, is a spherical seated ball bearing and is mounted in an oil-tight housing. A leather packing at each end serves to make the housing oil-tight.

Spicer or Layrub universal joints are used.

To remove Propeller Shafts

With Spicer universal joints, disconnect the flange of both the couplings of the rear half of the propeller shaft, slide the forward of the two couplings a little farther along its splines to disengage the spigot, and remove the rear half of the shaft complete.

Disconnect the flanges of the forward coupling, unbolt the intermediate bearing bracket from the cross-member, and the shaft can then be removed with the bearing in place.

The coupling at the forward end of both shafts can be removed by stripping it off the spline after first removing the knurled felt-retaining ring. That at the rear end of the rear half of the shaft is fitted to the shaft on a spline and locked by a nut.

To remove Layrub Coupling

Remove bolts securing coupling to each companion flange and prise the coupling away from each securing point in turn so as to disengage the spigots.

To remove Front Shaft complete with Centre Bearing

With Layrub joints, uncouple shaft at each end, leaving the universal coupling on the gearbox flange, and unbolt the centre-bearing housing. The shaft can now be removed from the rear, the hole in the cross-member being sufficiently large to enable the flange to pass through.

To remove Intermediate Bearing

Draw off the coupling flange, using the tool which is supplied in the tool-kit. Remove the cover over the bearing, and also the nut securing the ball bearing to the shaft, and tap the shaft out of the bearing and housing. The bearing may be tapped out of the housing.

Care must be exercised in handling this bearing, as the spherical is thin and is made only in soft steel. Leather packings, which are leaking, should be renewed.

Adjustment of the Spring Shackles

The shackles and the spring brackets should be kept adjusted so that the springs are just free but without having any real amount of slack.

To adjust, slacken off the clamp-bolts on the outer shackle, remove the split-pin from the nut on the shackle bolt and screw up the nut until just tight. Slacken off one half-turn, replace the split-pin, give the end of the

pin a tap with a hammer, in order to bring the clearance between the spring and the shackle, and tighten up the clamping bolts. The clamping bolts must always be kept screwed up tight.

The adjustment of the bracket at the forward end of the springs is performed in exactly the same manner. The side play is taken up by a sliding bush instead of drawing the shackles together, as in the case of the rear end.

To remove a shackle bolt, take out both clamping bolts and drive the pin out from the inside. In the case of the front shackle bolts of the front spring, the bolt may have to be drawn out, unless the radiator happens to have been removed, as with the radiator in position the inner end of the pin is not accessible.

Replacing the Springs

When replacing the springs, the greatest attention must be paid to tightening the axle bolts. This applies to both front and rear springs, but particular attention must be given to the rear ones. The bolts must be pulled up with a 4-ft. spanner, and all bolts of a spring tightened equally.

When assembling the shackles make sure that the slot in the pin for the clamping bolt is in line with the hole in the shackle.

After assembly, make sure that the oil-holes are lined up. This may be done by giving the shackle a liberal dose of oil and seeing that the oil gets out at both ends of both pins.

ROAD SPRINGS AND SPRING BUSHES

By GEORGE T. CLARKE, F.I.M.T.

(*Consulting Technical Editor to "Motor Commerce"*)

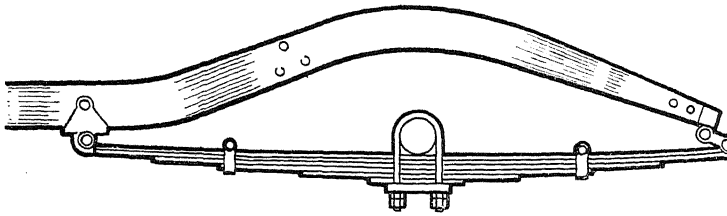
SPRINGS play a very important part in motor-car construction, but from their continued failure seem to have been somewhat neglected by the designer. On the other hand, those drivers who do have trouble with springs seem to be very much out of proportion to those who do not have trouble at all. Inquiry at large repair stations will prove that where springs fail it is mostly a failure on the part of the driver and not of any particular make of car. The great mortality in shock absorbers, however, leads to the supposition that the designer of the car places too much reliance on the absorber instead of the spring. Here, we are not dealing with the spring as fitted to the car in the first instance, but to the cause of failure and the repair and perhaps improvement of performance under the condition in which it has to function.

Causes of Spring Failure—Overloading

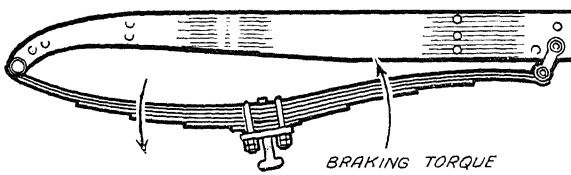
One great cause of trouble is overloading, especially at the rear of a car, when the driver carries a full complement of passengers and a pile of luggage on the rear carrier (Fig. 1). In this instance, the rear shackle is at such an angle that with each excessive bump it has a tendency to fracture the main leaf, on account of the angular movement being restricted, until, in one direction, it is almost solid with the spring. Observation often shows the rear springs in this condition before the start on a long journey over rough roads, either through actual overloading or through fatigue due to neglect. By many it is thought that the spring should last the life of the car if lubrication is carried out regularly, and without any other attention. Every part of every car should be inspected and the condition of the springs taken well into account.

Excessive Braking

Another form of trouble is caused by the driver who overstrains the springs, specially the front ones, by excessive braking (Fig. 2). The illustration is purposely exaggerated to show what happens when the driver pulls up suddenly and throws the whole car on its haunches, so to speak. It is admitted that in cases of emergency the spring should be capable of withstanding such strain, but where it is subjected to such misuse the spring should not be blamed for the inconsiderate action of the driver. This kind of inconsiderate driving is the cause of front-spring fractures, as shown in Fig. 3.

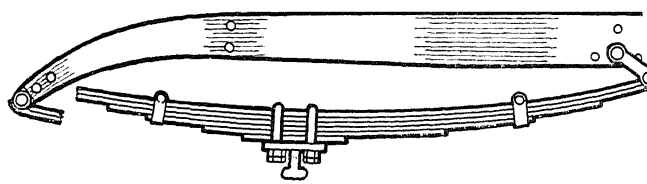


1 FLATTENED SPRING CAUSING INCORRECT ANGLE OF SHACKLE AND LEADING TO FRACTURE

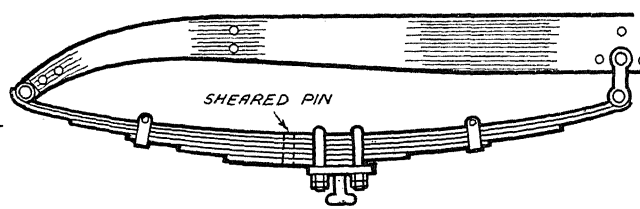


EXAGGERATED ACTION OF FRONT SPRING ON RAPID BRAKING

3 SEIZED SHACKLE PIN



4 LOOSE U-BOLTS OR SHEARED CENTRE BOLT



Figs. 1 *to* 4.—FAULTS IN SPRINGS AND THEIR CAUSES

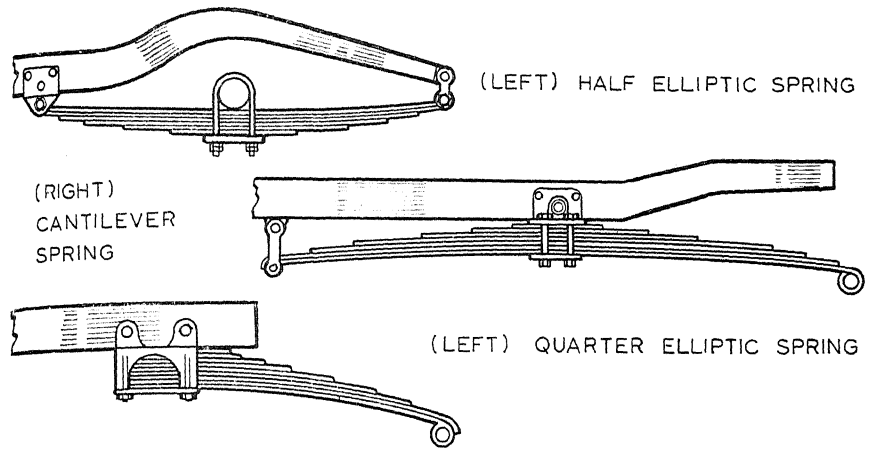


Fig. MAIN TYPES OF SPRINGS IN USE

Excessive braking leads to another trouble, in the form of the slacking off of the front spring U-bolts. The front axle should be continually checked, it being remembered that brakes on every car are more powerful than a few years ago, and with four-wheel brakes the leverage exerted by the driver has a tendency to pull the axles together, then, as the car slows up, the strain is released and the axles endeavour to take up their original positions. Brakes and their action is not part of this subject but are mentioned so that blame for failure should not be wholly placed on the design or material of the spring. Repeated spring failure can often be laid at the feet of the driver, although, as said, there is much need for a sound design.

Front-axle Movement

Front-axle movement will lead to the holding-down bolts moving along the spring, as shown in Fig. 4, and throwing more work on the spring centre bolt than it can possibly do.

Fit of the Centre Bolts

At this stage it may be as well to point out that all spring centre bolts should be a good fit, made of first-class mild steel, and that the head should actually fit the indentation in the spring platform. If they are properly made and from the right material, they will save many a spring fracture. Unfortunately, the writer has seen centre bolts that did not fit anyhow and could not, under any pretence whatever, be called a repair. Some bolts seem to have been made from any odd piece of iron, not steel, and so roughly screwed that on the slightest provocation the bolt fractured at the end of the badly cut thread. The thread should be allowed to " die out " on bolts of this description in exactly the same way as they do on a first-class big-end bolt.

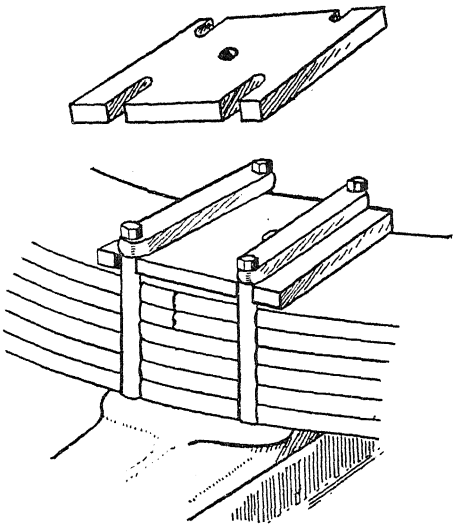


Fig. 6.—TEMPORARY REPAIR WHEN ARE BROKEN AT CENTRE

Types of Springs

Modern practice has eliminated the full elliptic spring, the main types of springing now used being the half-elliptic, quarter-elliptic, as on the Austin Seven ; and the cantilever spring, as on the Rolls-Royce, etc. On the Ford and one or two other cars, the half-elliptic spring is set transversely instead of longitudinally, but the action is the same in both instances. Fig. 5 shows the three springs mentioned.

In some forms of front-wheel springing a helical spring is used ; the spring gives little trouble, but the information as to adjustment is important and the instructions given with each design must be rigidly adhered to if the desired result is to be obtained. Instructions and advice are given for this type of springing in the articles dealing with the various cars.

Temporary Repair when Leaves are broken at Centre

Loose U-bolts lead to fractures of the spring at the centre, and frequently the trouble is not noticed until two or more leaves have given way. Fig. 6 gives an idea of a temporary repair until the failure can be dealt with at the end of the journey ; the cause of the trouble is neglect.

The stock sizes of spring steels of all qualities are given in Table I.

TABLE I

STOCK SIZES OF SPRING STEELS

Width in inches	*Thickness in inches*							
1	1/16	1/8	3/16	1/4				
1 1/8	3/16							
1 1/4	1/16	1/8	3/16	1/4	5/16	3/8		
1 3/8	1/4							
1 1/2	1/16	1/8	3/16	1/4	5/16	3/8		
1 5/8	1/4							
1 3/4	1/16	1/8	3/16	1/4	5/16	3/8	1/2	
2	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8
2 1/4	1/8	3/16	1/4	5/16	3/8			
2 1/2	1/8	3/16	1/4	5/16	3/8	7/16	1/2	
2 3/4 and 3	1/8	3/16	1/4	5/16	3/8	7/16	1/2	
3 1/4	1/8	3/16	1/4	5/16	3/8			
3 1/2	1/8	3/16	1/4	5/16	3/8	1/2		
3 3/4	1/8	3/16	1/4	5/16	3/8			
4	1/8	3/16	1/4	5/16	3/8	1/2		

(*Buck & Hickman Limited*)

The Spring Steel Used

Car manufacturers, owing to requirements, are not now using ordinary carbon spring steel for spring making, but an alloy which stands up to the strain much better than plain spring steel, as shown in Table II.

TABLE II

COMPOSITION OF SPRING STEELS

Physical Properties			*Chemical Analysis*					
Steel	*Yield lb. sq. in.*	*Tensile Strength lb. sq. in.*	*C%*	*Mn%*	*Si%*	*Ni%*	*Cr%*	*Va%*
Carbon	145,600	123,000	·55	·6	·2	—	—	—
Chrome-Van.	184,800	194,000	·46	·57	·17	·15	1·4	·18
Silico-Man.	172,200	197,600	·52	1·05	1·95	—	·05	—

It will be noticed that the plain carbon steel has the lowest tensile strength, that chrome-vanadium has better strength, whilst silico-manganese has the highest tensile strength.

Whatever spring steel is used, the operator should stick to the same make and same quality so that he can, with certainty, master the hardening and tempering. It is not good to change around the steel used, as it gives the smith no chance whatever to gauge his material and manipulate it according to the varied requirements. The advice is, find the steel best suited to your purpose, both in requirements and the equipment at your command, master the working of the material, and then keep a good supply. One can never be sure of a good spring if the operator has to deal with a length picked up locally and which may be named a certain brand only so that a sale is effected.

Hardening and Tempering

Dealing with the hardening and tempering of spring leaves, the advice given is for the average garage repair shop, and not the smith's shop where springs are made on a large scale, the process in such a shop being entirely different from that practised by the ordinary spring-smith, using the ordinary hearth and small-shop system of hardening.

Judging the Temperature of the Steel

Any form of smithing entailing the hardening of steel must be carried out in semi-darkness, and the light entering the shop should not vary. In sunlight it is impossible to state the condition of the heated metal by colour, and it is by colour that the smith gauges his workmanship. A passing cloud will make all the difference in the appearance of a piece of

red-hot iron or steel, as there are varying degrees of "red hot." Overheating steel used for springs is fatal, as no one knows better than the practised smith.

TABLE III

HIGH TEMPERATURES JUDGED BY COLOUR IN A CORRECTLY LIGHTED BLACKSMITH'S SHOP

Degrees Centigrade	*Degrees Fahrenheit*	*Colour*
400	752	Red heat visible in dark
475	885	Red heat visible in twilight
525	975	Red heat visible in daylight
581	1077	Red heat visible in sunlight
700	1292	Dark red
800	1472	Dull cherry red
900	1652	Cherry red
1000	1832	Bright cherry red
1100	2012	Orange-red
1200	2191	Orange-yellow
1300	2372	Yellow-white
1400	2552	White welding heat
1500	2732	Brilliant white
1600	2912	Dazzling white

The Hardening Tank

The average spring steel should be brought to about 1,652° F., and plunged into clean cold water. If the forge bosh is not long enough the hardening should be done in a tank kept for the purpose. The writer has seen first one end and then the other end plunged in a small dirty bosh, and the operator wonder why his job has failed. If a special tank is used for the purpose, a handful of common salt can be added to increase the conductivity of the water. The tank, when not in use, should be covered, as it is likely to form the receptacle for anything not wanted by passers-by.

Tempering

Tempering is the after-process to bring down the hardness of the spring leaf to a working degree. The degree of tempering is about 426° C., or 800° F. The average smith heats the hardened leaf in a clean, dull fire and tries the heat with a piece of apple-wood. Apple-wood is not used because the original smith's shop started in the country and a piece of apple-wood came first to his hand, but because this tree suited his purpose in testing the heat he required. When the piece of apple-wood, stroked along the surface of the leaf, gives out sparks, plunge again into clean water, or oil, and allow to cool right off.

Tempering Oil

The oil mostly used by smiths for tempering is whale oil or some proprietary oil sold specially for the purpose, but the operator must not confuse the flash-point of an oil with the "fire test" of the same oil.

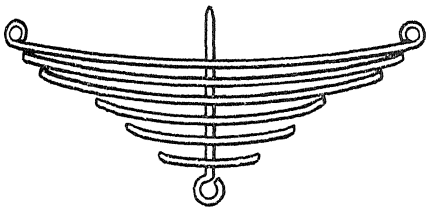


Fig. 7.—METHOD OF BUILDING UP A SPRING

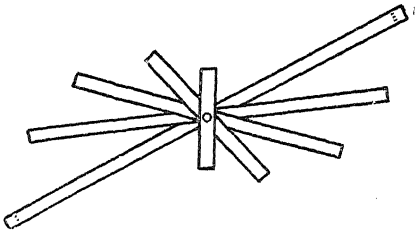


Fig. 8.—ASSEMBLING SPRING WITHOUT VICE

The distinction is as follows : The flash-point is the temperature at which the amount of vapour given off is sufficient to form an explosive mixture with the air over the surface of the oil so that it flares up when a flame is applied. When the oil is painted on a hot piece of iron or steel and the vaporisation is sufficiently rapid to light the oil and maintain the flame so that the oil takes fire and burns, the " fire test " point has been reached ; therefore in obtaining oil for your purpose be sure to give the correct definition.

Building up New Spring

In making up a new spring, the leaves will be compassed as in Fig. 7. The object in abutting the ends only is so that, when the spring is bolted up and used under working conditions, the whole of the leaves will be under stress, otherwise the ends would splay somewhat and do no work. The work is best carried out by laying the leaves on a large surface-plate (not of good quality, but of the type seen in the average smith's shop) so that the distance between the centre of each leaf can be gauged. Before final assembly the spring should be tried out to see if every leaf fits snugly to its fellow. This can be done with a large metal skewer through the centre-bolt holes, and the spring under a press of some sort.

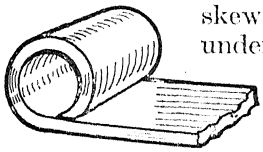


Fig. 9.—CORRECT FORMATION OF SPRING EYE

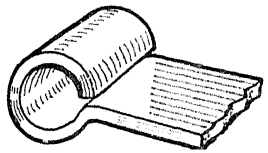


Fig. 10.—INCORRECT FORMATION OF SPRING EYE

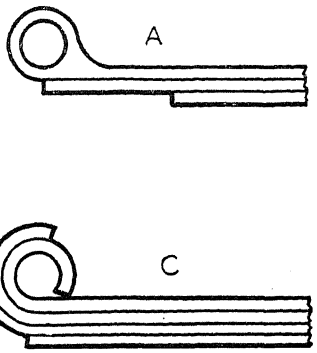


Fig. 11.—VARIETIES OF SPRING EYES AND MAIN LEAVES

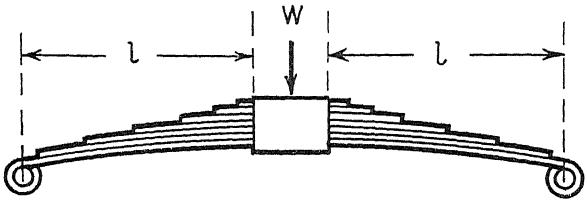


Fig. 12.—ILLUSTRATING LENGTH OF SPRING FOR CALCULATION PURPOSES

Final Assembly

To finally assemble the spring one may lay the leaves in their correct order but in the form of a star, so that the centre bolt can be installed and with the nut fitted on a few threads only to ensure its not coming off. The leaves can then be slipped round into the right direction, after which the centre-bolt nut can be finally tightened. Do not do up the nut until the bolt is ready to burst with the strain, but remember that it has work to do and is not merely for the purpose of keeping the leaves in their correct order (*see* Fig. 8).

Forming the Spring Eyes

In forming the spring eyes note the correct and incorrect formation clearly shown in Figs. 9 and 10.

Fig. 11 shows some of the main leaves that will be met with in the repair shop. It is not an economical proposition to make up a new leaf as at *A*, but if the shackle permits it is wise to shape leaves as at *C*, thus maintaining strength even if one does not follow actual design. The approved eye for insertion of the "Silentbloc" bush will be dealt with later.

Some Useful Spring Calculations

It may be necessary to make up springs, either on account of increased load, or to know what was originally intended by the designer. There are many reasons apart from actual manufacture why the repairer should be able to calculate springs, and as many workmen have no flair for figures the formula is given in as simple a form as possible.

Let S = fibre stress, assumed as 80,000 lb. per square inch for carbon spring steel.
E = modulus of elasticity = 25,400,000.
W = maximum carrying capacity of spring.
F = deflection of spring under load.
n = number of leaves in the spring.
b = width of leaves.
L = length of spring, less length of holding-down plate, or $l \times 2$ (*see* Fig. 12).

Example

A spring has 5 *leaves,* 2 *in. wide and* $\frac{1}{4}$ *in. thick, and the effective span is* 33 *in. What is the maximum carrying capacity ?*

The formula is $\frac{2\,Snbh^2}{3L}$, or

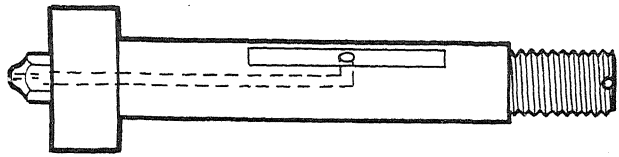


Fig. 13.—PLAIN SHACKLE PIN AND GREASE NIPPLE

$$\frac{2 \times \text{Fibre stress} \times \text{number of leaves} \times \text{thickness of leaves}^2}{\text{3 times length of spring minus holding-down plate}} \text{ or}$$

$$\frac{2 \times 80{,}000 \times 5 \times 2 \times \cdot25^2}{3 \times 33} \text{ or } \frac{100{,}000}{99} = 1{,}010{\cdot}1 \text{ lb.} =$$

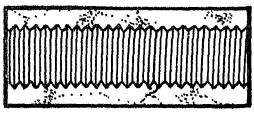
the maximum carrying capacity of the spring.

Another formula, giving a lower reading, and useful when one does not know the nature of the material, but assuming it is not higher than carbon steel, is $\frac{53{,}000\, nbh^2}{L}$ or $\frac{53{,}000 \times 5 \times 2 \times \cdot25^2}{33}$ or $\frac{530{,}000 \times \cdot0625}{33}$ or $\frac{33{,}125}{33} = 1{,}003{\cdot}4$ lb. as the maximum capacity of the spring.

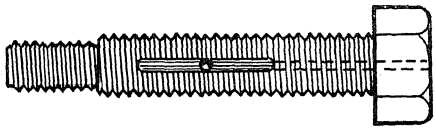
The deflection of the same spring would be, using the formula : $\frac{SL^2}{4\,Eh}$ or $\frac{80{,}000 \times 33^2}{4 \times 25{,}400 \times \cdot25}$ or $\frac{80{,}000 \times 1{,}089}{25{,}400{,}000}$ or $\frac{87{,}120{,}000}{25{,}400{,}000} = 3{\cdot}429$ in. deflection.

Another formula, if in doubt as to the spring steel, is : $\frac{\cdot00079 \times L^2}{h}$ or $\frac{\cdot00079 \times 33^2}{\cdot25}$ or $\frac{\cdot00079 \times 1{,}089}{\cdot25}$ or $\frac{\cdot84031}{\cdot25} = 3{\cdot}44$ in. deflection.

The accompanying half-elliptic spring table compiled by *Machinery* in their handbook is a short and easy method of calculating half-elliptic springs, both for safe load and for the deflection with the same load. W is the safe load and F the deflection. The table is based upon a modulus of elasticity of 25,400,000, and a fibre stress under maximum load of 80,000 per square inch when all the leaves are fully graduated. The safe load on one leaf, 1 in. wide, is found by dividing the constant

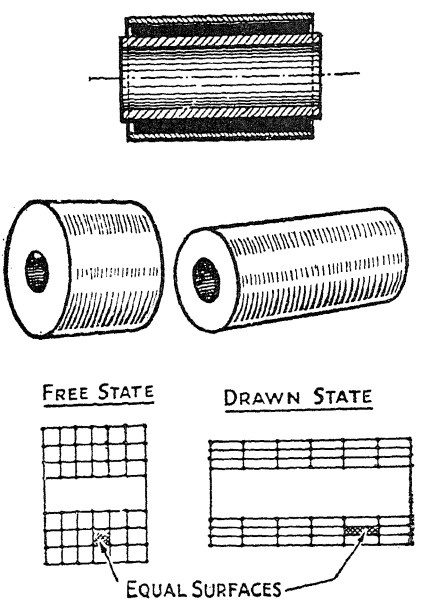


SECTION OF DAIMLER SPRING EYE BUSH



SHACKLE PIN (SCREWED)

Fig. 14.—DAIMLER SCREWED BUSH AND PIN



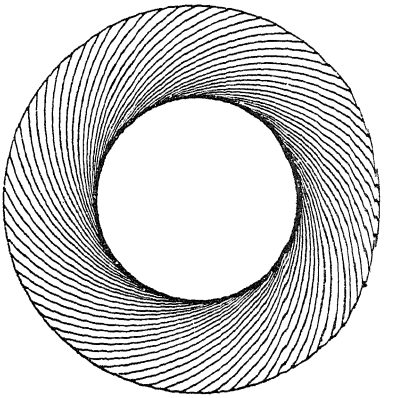


Fig. 15.—PRINCIPLES OF FORMATION OF "SILENTBLOC" BUSH

The upper pair of sketches on the left show the rubber bush before and after fitting. In the process of fitting, the material is compressed radially, as indicated by the diagrammatic sections shown in the corresponding lower pair of sketches on the left.

given in column *W* by the net span *L*. The corresponding deflection is found by multiplying the constant given in column *F* by the square of the net length of *L*.

TABLE IV

HALF-ELLIPTIC SPRING TABLE

Thickness of leaf in inches	*Constants*	
	W	*F*
$\frac{3}{16}$	1875	·00420
$\frac{1}{4}$	3333	·00315
$\frac{5}{16}$	5208	·00252
$\frac{3}{8}$	7500	·00210
$\frac{7}{16}$	10210	·00180
$\frac{1}{2}$	13330	·00157
$\frac{5}{8}$	20830	·00126

From *Machinery's Handbook.*

Example

Find the safe load of a half-elliptic fully graduated spring with 5 *leaves* 2 *in. wide and* $\frac{1}{4}$ *in. thick. The net length is* 36—3, *therefore the effective length is* 33 *in.*

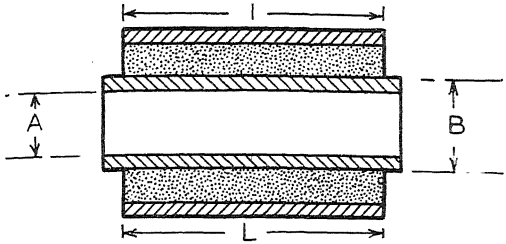


Fig. 16.—THE " SILENTBLOC " BUSH

A, Bore of inner tube. B, Outside diameter. L, Length of inner tube. I, Length of outer tube.

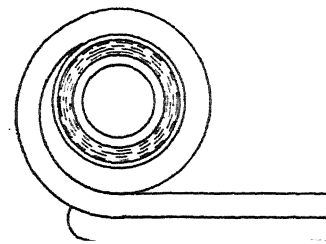


Fig. 17.—APPROVED SPRING EYE FOR " SILENTBLOC " BUSH

Load on one leaf 1 in. wide equals $\frac{3,333}{33}$ or 101·01 lb.

Load on one leaf 2 in. wide is therefore 2 × 101·01 or 202·02 lb.
Load on five 2-in. leaves is 5 × 202·02, totals 1,010·1 lb.
The corresponding deflection is :

$$\cdot 00315 \times 33^2 \text{ or } 3{\cdot}43 \text{ in.}$$

Shackle Pins and Bushes

For many years shackle pins and bushes were but a primitive method of securing the spring to the chassis frame. The supply of lubricant was haphazard, and both pin and bush, by being smothered with grease on the outside, gathered all the road dust, thus forming an excellent abrasive with which to wear out the whole of the securing mechanism. Fig. 13 will be recognised as the very poor effort in this direction.

The Daimler Company introduced an improvement in the nature of a bush screwed inside, with a hardened pin screwed on the outside. This was very satisfactory in the fact that it prevented " slogger " within the shackle (one of the forms of wheel wobble with a neglected spring anchorage). It also offered a larger wearing surface.

The " Silentbloc " Bush

In latter years the majority of manufacturers have installed what is known as the " Silentbloc " bush. A description of the principle may therefore be of some assistance, along with the tolerances of the most popular sizes used.

This form of bush consists essentially of an inner bush or tube and an outer concentric sleeve, the space between being filled with an elastic and insulating material in the form of a cylindrical ring, which is forced into position. In the assembly of the elastic ring, the longitudinal fibres are stretched, and when in position between the sleeves the effort made by the ring to regain its original shape exerts a radial compression force of such intensity that no slip can take place between the elastic ring and the sleeves. The result is that all relative movement between the centre

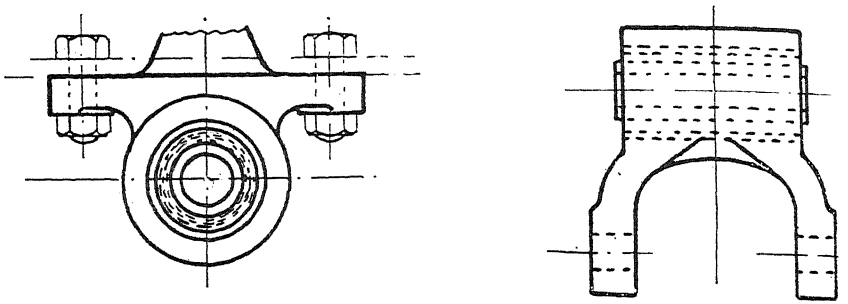


Fig. 18.—"SILENTBLOC" BUSHES IN CHASSIS BRACKETS AND SHACKLES

and the outer tubes is limited to a circular direction only, and consequently any angular movement of the one part in relation to the other is possible without any friction or wear taking place, namely, angular movement only and not rotative. It will be seen the principle is entirely different from either of the bushes previously described.

TABLE V

"SILENTBLOC" BUSHES (Letters A, B, L, I refer to *Fig.* 16)

Series E.1000 and E.2000 (English Dimensions)

Limits of Manufacture

Outside Diameter	*Inches*			
Inches	A	B	I	L
$\frac{9}{16}$–$\frac{11}{16}$	+ ·003 — 0	+ ·002 — 0	+ ·005 — 0	+ ·002 — 0
$\frac{3}{4}$–$\frac{7}{8}$	+ ·005 — 0	+ ·002 — 0	+ ·005 — 0	+ ·002 — 0
$\frac{7}{8}$–5$\frac{1}{2}$	+ ·005 — 0	+ ·005 — 0	+ ·005 — 0	+ ·002 — 0

Series M.1000 and M.2000 (Metric Dimensions)

Limits of Manufacture

Outside Diameter	*Millimetres*			
Millimetres	A	B	I	L
6–10	+ ·05 — 0	+ ·05 — 0	+ ·10 — 0	+ ·10 — 0
11–24	+ ·075 — 0	+ ·05 — 0	+ ·10 — 0	+ ·10 — 0
25–34	+ ·075 — 0	+ ·10 — 0	+ ·10 — 0	+ ·10 — 0
35–38	+ ·10 — 0	+ ·10 — 0	+ ·10 — 0	+ ·10 — 0

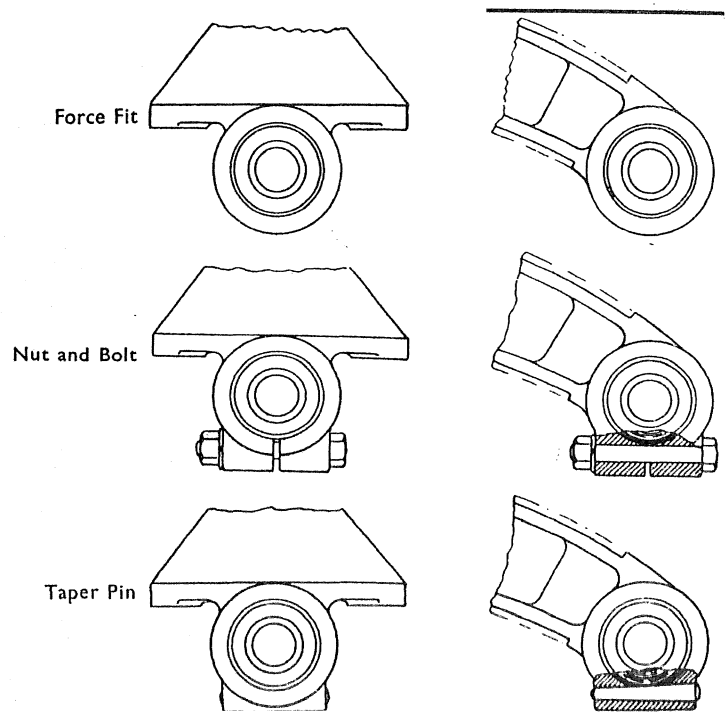


Fig. 19.—Methods of fixing "Silentbloc" bushes to chassis brackets and solid dumb-irons

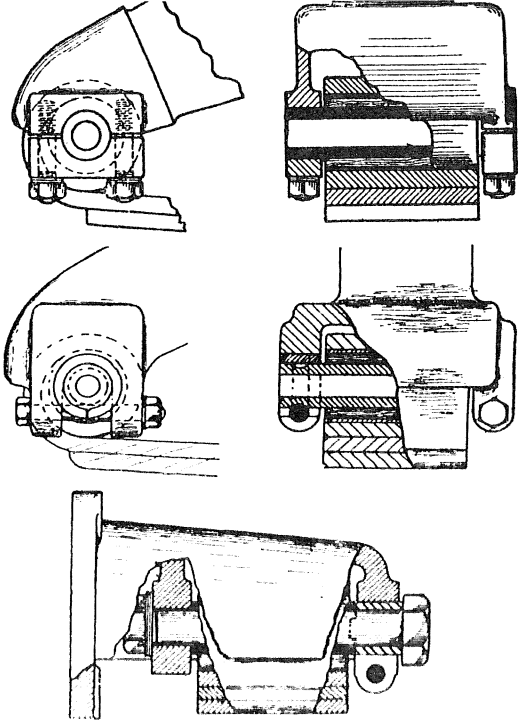


Fig. 20. Methods of fixing "Silentbloc" bushes to commercial-vehicle dumb-irons

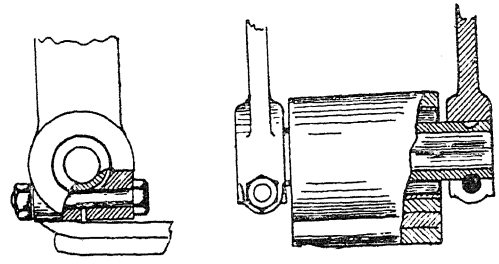


Fig. 21.—"SILENTBLOC" BUSH IN COMMERCIAL-VEHICLE SHACKLE

The permissible angular movement allowed by the stretch of the radial fibres is limited only by the fact that the external torsional movement applied must be less than the internal movement of resistance given by the frictional force of the elastic ring on the surfaces of contact.

The angle of torsion can be varied by an alteration to the dimensions of the elastic ring before assembly. In practice, approximately 20°–45° of movement on either side of the neutral position is allowed for, and this can be increased or decreased by any particular application. If the angular movement allowed be exceeded, slip will take place between the elastic ring and the sleeve, with the result that the "Silentbloc" will then, momentarily, function as an ordinary bearing. It is, however, important to note that in this case the "Silentbloc" will take up a new neutral position and will function correctly through a given angle on either side of the new point taken up.

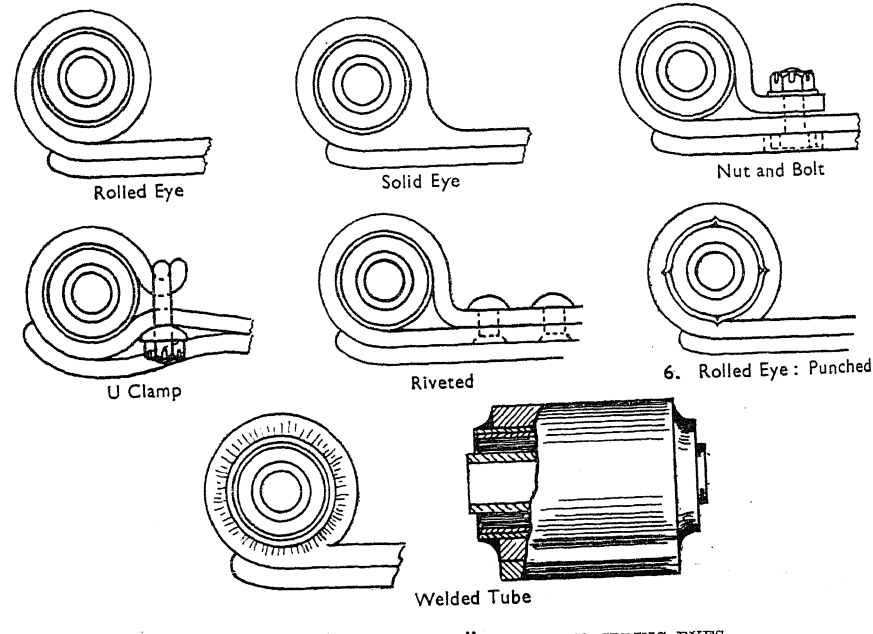


Fig. 22.—FIXING "SILENTBLOC" BUSHES TO SPRING EYES

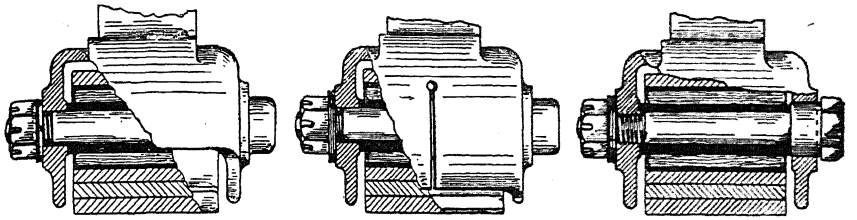


Fig. 23.—"SILENTBLOC" BUSHES FIXED TO OPEN DUMB IRONS AND CHASSIS BRACKETS
The sawcut in the housing gives greater flexibility.

It will be noted that all lateral or end movement is limited, although for other purposes this bush can be made to permit end play. This is not necessary with its application to the springing of cars.

It will be apparent that the adhesion of the elastic ring to the inner and outer sleeves, in addition to allowing angular movement without friction, provides an airtight joint against liquids and gases; further, owing to the composition of the bushing it tends to absorb tremors and vibration (*see* Fig. 15).

Fig. 16 illustrates the bush, whilst Tables V–VII give the limits to which they are manufactured.

TABLE VI

TOLERANCES FOR PRESS FITS IN SPRING EYES (*see* Fig. 17)

English sizes		*Metric Sizes*	
Nominal diameter of Silentbloc (outside) Inches	*Limits in Spring Eye Inches*	*Nominal diameter of Silentbloc (outside) Millimetres*	*Limits in Spring Eye Millimetres*
$\frac{9}{16}$–$\frac{7}{8}$	— ·010 — ·020	21–25	— ·30 — ·60
$\frac{15}{16}$–$1\frac{1}{8}$	— ·016 — ·026	26–29	— ·40 — ·70
$1\frac{3}{16}$–$1\frac{3}{8}$	— ·025 — ·035	30–35	— ·60 — ·90
$1\frac{7}{16}$–$1\frac{5}{8}$	— ·028 — ·038	36–40	— ·70 — 1·00
$1\frac{11}{16}$–$2\frac{1}{8}$	— ·034 — ·044	41–54	— ·80 — 1·20
$2\frac{3}{16}$–$2\frac{3}{4}$	— ·040 — ·055	55–70	— 1·00 — 1·40

Silentbloc Arrangements

The standard Silentbloc has a comparatively thin inner tube, through which the bolt passes. It is, however, possible to use a much thicker tube or even a solid centre which would project either end, in which case a bolt would not be necessary.

TABLE VII

TOLERANCES FOR CHASSIS BRACKETS AND SHACKLES (*see* Fig. 18)

English Sizes		*Metric Sizes*	
Nominal outside diameter of Silentbloc Inches	*Limits in Bracket Inches*	*Nominal outside diameter of Silentbloc Millimetres*	*Limits in Bracket Millimetres*
$\frac{5}{16}$–1 $\frac{9}{16}$	— ·002 — ·003	21–40	— ·05 — ·07
1 $\frac{5}{8}$–2	— ·0025 — ·0035	41–50	— ·06 — ·08
2 $\frac{1}{16}$–4	— ·003 — ·004	51–70	— ·06 — ·085
		71–80	— ·06 — ·09

With the smaller sizes of Silentbloc, the friction at the end of the inner tube is sufficient to prevent rotation, but with the larger sizes it is advisable to have a positive fixing. Several approved methods are shown in Figs. 19, 20, and 21. The usual method of fixing the outer tube is by force-fit in the bracket or spring eye, and this has been found satisfactory for all sizes. The bush should always be assembled in its neutral position, so that the angular movement is the same in both directions. Always press on the outer tube when assembling, and never on the inner tube.

Many shackle-bolt housings were not originally intended to take the Silentbloc bush, but when this bush is fitted it is as well to make a saw-cut down the housing, as Fig. 23, so that the inner tube of the bush can be pinched tightly. The cover on the bracket, or shackle, was intended to stiffen the housing so that the spring could not be pinched. As the situation is now entirely reversed, the saw-cut is an advantage, and not, as may be supposed, a method of surmounting an unforeseen difficulty.

Helical Springs

The various forms of front suspension mostly use round helical springs, but the design and layout of the various methods are given under the headings of the suspension themselves, therefore it will be necessary in this article to deal only with the value of the springs, leaving it to the other sections to describe how they are actually used.

The formula is somewhat lengthy and complicated, but it is hoped that the undermentioned information will assist the operator or mechanic to locate their values.

All dimensions are in inches and weights in pounds.

W = maximum load in pounds or the load equivalent to the maximum deflection.

W_1 = in pounds equivalent to any deflection less than the maximum.

D = the mean diameter of the spring in inches = the outside diameter minus the wire diameter.
d = diameter of the wire.
F = total deflection in inches from free to the fully compressed length.
F_1 = any deflection from the free length but less than the solid length.
A = deflection between two loads.
N = length of free or unloaded spring.
h = length of spring when compressed solid.
H = number of effective working coils. This value is usually $1\frac{1}{2}$ or 2 less than the total number of coils for springs having squared ends.
L = length of wire from which the spring is made.
G = torsional modulus of elasticity (10,500,000).

The formulas and examples all deal with a helical spring having an outside diameter of 3·5 in., a wire diameter of 0·5 in., and a modulus of elasticity of 10,500,000 lb.

Required to find the maximum load (W) *for the maximum deflection* (F)

$D = 3{\cdot}5 - 0{\cdot}5 = 3$ in.
$H = 10{\cdot}5$ in. ; $h = 6$ in.
$F = 10{\cdot}5 - 6 = 4{\cdot}5$ in.
$N = h + d - 2 = 6 \div 0{\cdot}5 - 2 =$ *active coils.*

The formula is :

$$W = \frac{Gd^4F}{8ND^3} \text{ or } \frac{10{,}500{,}000 \times 0{\cdot}5^4 \times 4{\cdot}5}{8 \times 10 \times 3^3} \text{ or } \frac{10{,}500{,}000}{10} \frac{0{\cdot}0625 \times 4{\cdot}5}{} \text{ or } \frac{2{,}953{,}125}{2{,}160} = 1{,}367 :$$

(in round figures) 1,370 lb.

Another example :

Load required (W_1) *for any deflection* (F) :

$D = 3{\cdot}5 - 0{\cdot}5 = 3$ in.
$F_1 = 2{\cdot}5$ (*assumed value*).
$N = 6 \div 0{\cdot}5 - 2 = 10$ *active coils.*

The formula is :

$$W^1 = \frac{Gd^4F_1}{8ND^3} \text{ or } \frac{10{,}500{,}000 \times 0{\cdot}5^4 \times 2{\cdot}5}{8 \times 10 \times 3^3} \text{ or } \frac{1{,}640{,}625}{2{,}160} = 759$$

(in round figures) 760 lb.

Another example :

Total deflection from free to solid (F) *length :*

$W = 1{,}370$ lb.
$N = 6 \div - 2 = 10$ *active coils.*
$D = 3{\cdot}5 - 0{\cdot}5 = 3$ in.

The formula is :

$$F \frac{W8ND^3}{Gd^4} \text{ or } \frac{1{,}370 \times 8 \times 10 \times 3^3}{10{,}500{,}000 \times 0{\cdot}5^4} \text{ or } \frac{1{,}370 \times 80 \times 27}{656{,}250} \text{ or } \frac{2{,}959{,}200}{656{,}250}$$

4·5 in.

Last example :

Deflection required (F_1) *for any load less than* W :

$W_1 = 760$ *lb.*

$N = 6 \div 0{\cdot}5 - 2 = 10$ *active coils.*

$D = 3{\cdot}5 - 0{\cdot}5 = 3$ in.

The formula is :

$$F_1 = \frac{W_1 8 N D^3}{G d^4} \quad \frac{760 \times 8 \times 10 \times 3^3}{10{,}500{,}000 \times 0{\cdot}5^4}$$

$$= \frac{1{,}641{,}600}{656{,}250} = 2{\cdot}5 \text{ in.}$$

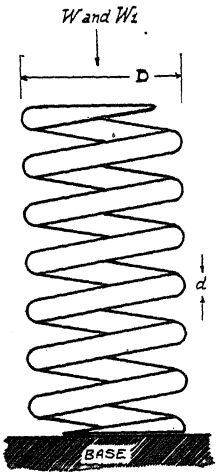


Fig. 24.—HELICAL SPRING

It is as well to remember that some of the steel from which springs are made is of special quality, both for strength and the resistance to the atmosphere and acids ; therefore the operator should obtain from the manufacturer the data on which the particular material is based.

SPRING ASSEMBLY HINTS

Spring Wedges and Steering Castor Action

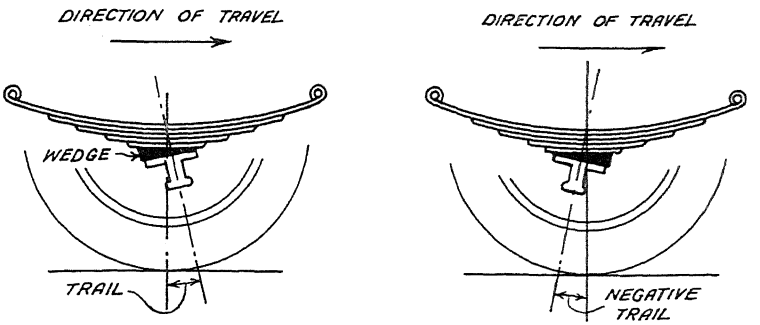
In order to introduce or increase the castor action of the front wheels of a car, wedges are sometimes fitted between the front springs and the axle plates so as to incline the steering pivot pins backwards, as shown in Fig. 25. Each wedge consists of a piece of tapered metal with a hole in the centre for the spring dowel pin to pass through.

In replacing a spring care should be taken not to omit the wedge, with the possible exception of a case where the springs have just been reset, the wedges having been previously fitted solely for the purpose of correcting " S " distortion of the spring caused by breaking torque. In such a case the wedges may be omitted if the springs have been restored to their correct shape.

It is even more important that the wedges be replaced in the correct manner, for if they be reversed, with the thin end of the taper to the rear, the steering king pins will be inclined forward, thus introducing negative trail and making the steering practically uncontrollable.

Location of Centre Bolt

The wedges should not be so thick that the head of the spring centre bolt does not engage with the hole in the axle spring table, otherwise the axle may creep out of position. On the other hand, should a wedge be removed it is advisable to ascertain that the head of the bolt is not too long, for if it should bottom in the hole it would be impossible for the spring to seat properly. On tightening the U-bolts the tendency would



Figs. 25 and 25a.—FRONT SPRINGS ARE SOMETIMES FITTED WITH WEDGES BETWEEN THE SPRINGS AND THE AXLE

It is important when fitting the springs to replace these wedges with the thin edge forward, for if they be reversed the castor action will be negatived and the steering will become unmanageable.

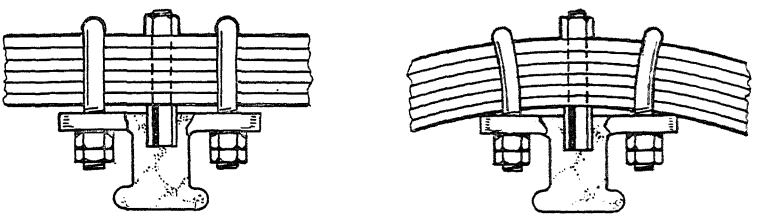


Fig. 26.—LOCATION OF CENTRE BOLT

Should the dowel head of the centre bolt bottom in the hole in the axle spring table the spring will not seat properly, and on tightening the U-bolts both the spring and the U-bolts may be bent, with the added risk of shearing the bolts or causing a spring fracture.

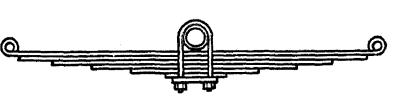


Fig. 27.—A FLAT SPRING SHOULD NOT BE CONFUSED WITH ONE WHICH IS DESIGNED WITHOUT CAMBER AS SHOWN HERE

The position of the shackles will reveal the difference; with the former the shackle assumes an acute angle, whereas with the latter it is approximately vertical under normal load.

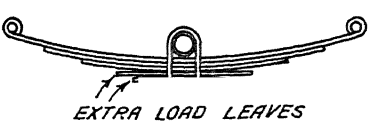


Fig. 28.—ADDITIONAL LEAVES EITHER FLAT OR OF REVERSE CAMBER ARE SOMETIMES FITTED TO A SPRING

They come into operation under heavy loads and should not be reversed or set up.

SPRING ASSEMBLY HINTS

be to pull the spring out of shape, if not to break it, as shown in Fig. 26. There is also a likelihood of the U-bolts snapping due to the additional strain imposed.

Flat Springs and Supplementary Leaves

Because a spring appears to be flat it does not necessarily follow that it has become soft or "settled," since it may be designed with little or no camber. A rough and ready way to differentiate between the two conditions is to examine the position of the shackles. When a cambered spring flattens, the increased length causes the shackle or shackles to assume almost a horizontal position, but with a normally flat spring the shackles are more or less vertical under ordinary load conditions.

Sometimes the first one or two of the shorter leaves of a spring are flat or have reversed camber so that they stand away from adjacent leaves, as illustrated in Fig. 28. This should not be confused with the splayed leaves of a weak spring. The idea of these supplementary leaves is to provide the right degree of spring strength under varying conditions of load. Thus, when the car is lightly loaded the upper leaves only are operative, but when the load is increased the additional flexion of the spring brings the supplementary leaves into action so that the stiffness of the spring increases with the increase in load. These supplementary leaves should not be reversed when reassembling the spring, nor should they be set up.

VEHICLE BRAKE TESTING

THE first requirement in carrying out brake tests on any vehicle is a thorough understanding of what one is about to measure and the type of brake performance which can be expected under the prevailing conditions, together with the possibilities of the available measuring instrument or machine.

How Road Conditions Affect Braking

In the first place the brake force on the speed of a vehicle is limited finally by the friction between its tyres and the ground. The value of this friction varies widely according to prevailing conditions. On suitable roads, with good tyres, steering, and road holding, values of unity coefficient of friction, or even slightly over, have been recorded. On a wet, ice-bound road, on the other hand, the same vehicle may give an adhesion coefficient of friction of ·1 or even less, in spite of the fact that the vehicle and its brakes are still in the same excellent condition. In the first case, it will be possible to make use of a braking force equal to or even slightly in excess of the car's own weight, whereas under the latter condition any attempt to use a force more than $\frac{1}{10}$th of the vehicle's weight will put it out of control.

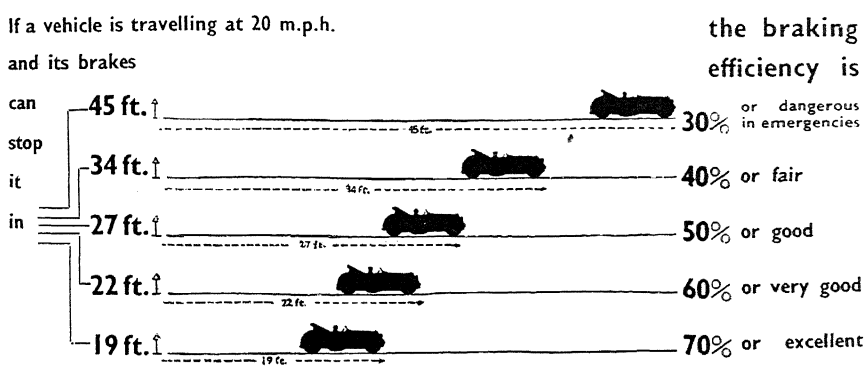


Fig. 1.—STOPPING DISTANCE AND BRAKING EFFICIENCY AT 20 MILES PER HOUR ON GOOD DRY LEVEL ROADS

In this country, the police generally insist on a minimum of 30 per cent. braking efficiency. With brakes and linings in good order, the average commercial vehicle, unless grossly overloaded, will give a value of around 50 per cent. and modern private cars 70 per cent. and over on good dry level roads.

What is meant by 100-per-cent. Brake Efficiency

Perhaps the principal law covering any change of speed of a vehicle in horizontal motion is that a force equal to its own weight will, when acting on it, increase or decrease its speed by 22 m.p.h. for every second the force is in action. Similarly, a force equal to half the vehicle's weight will change its speed by 11 m.p.h. during each second it is in action, and so on for any other proportion the force may bear to the vehicle's weight. All tables giving stopping-distances at different speeds and brake performances are based on this fact, and the acceptance by the motor trade and users generally that a coefficient of friction between tyres and road of unity with its corresponding maximum brake force represents 100 per cent. braking.

How the Stopping-distance Varies with the Speed

It will be seen from any braking chart that, for a given braking performance, stopping-distance increases as the square of the speed, i.e. if the speed is doubled the stopping distance is four times as great, and this again depends upon the facts already stated. If a vehicle travelling at 30 m.p.h. is braked by a force equal to its own weight, it will lose 22 m.p.h. per second and will therefore take approximately 1·36 secs. to lose 30 m.p.h. and come to rest. Providing the brake force is constant, its average speed during braking will be half its initial speed, or 22 ft. per second, and as this average speed is maintained for 1·36 secs. the stopping-distance will be 30 ft. For the same brake performance, however, from 60 m.p.h. the time taken in losing all speed will be twice as long, or 2·72 secs., but in addition the average speed during the stopping-time will be twice as great, or 44 ft. per second, thus giving a stopping-distance of 120 ft., or four times that from 30 m.p.h.

Why Stop-watch Brake Testing is Inefficient

Accurate brake testing is impossible without the aid of some form of instrument or machine. The old methods of applying a vehicle's brakes when passing a mark at the side of the road and subsequently measuring the stopping-distance, or the alternative stop-watch measurement of braking time, both of which introduce the human element and speedometer errors, should, by now, be extinct. An error of plus or minus 2 m.p.h. at 20 m.p.h. will create a similar error of 20 per cent. in estimating whether a set of brakes is satisfactory or not. Similarly, at the same speed an anticipation or lag, by the driver, of $\frac{1}{5}$th of a second in applying the brake will cause a further error of around 30 per cent., and it will be impossible to say whether this latter error is in addition to or corrects a faulty speedometer reading. Timing the duration of the stop introduces errors of a similar magnitude.

Fixed Floor Brake-testing Machines

Equipment for road-vehicle brake testing can be divided into two classes—machines and instruments. The machines, which are difficult or impossible to use on the road, measure the individual brake force exerted at each tyre periphery when the brakes are applied, and again can be divided into two types.

The first type is equipped with a pair of rollers for each wheel, the vehicle is driven on to these rollers, movement of the vehicle prevented by anchoring the front axle or some other rigid portion of the vehicle's chassis to an external anchorage, and the rollers are driven either by power or manually. The vehicle's brakes are applied by means of a pedal effort, and the resulting brake resistance at the effective tyre radius of each wheel is indicated by a transmission dynamometer in the roller drive which continuously weighs the braking force.

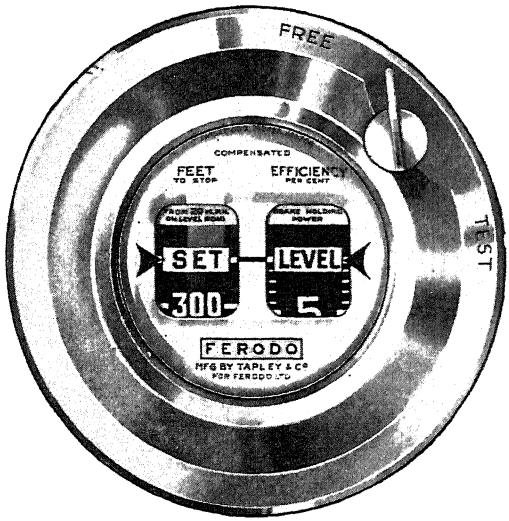


Fig. 2.—THE FERODO BRAKE-TESTING METER

The instrument is mounted on the car and set to zero. The car is then driven at any speed over 10 m.p.h. and the brake applied. The percentage efficiency of the brake and the distance in feet in which the car can be stopped from a speed of 20 m.p.h. can be read off the two scales. A table giving the corresponding stopping distances from other speeds is shown on page 492.

These machines usually give a direct reading for each wheel in terms of lb. drag at effective tyre radius. This type of machine is manufactured in a range of sizes from the light type, consisting of a single unit which can be applied individually to each wheel in turn and turned by hand to obtain a reading, to the large, heavy type in which each pair of rollers is driven by an individual motor and the machine is sunk into the sides of an inspection pit with the rollers at floor level. This latter type of machine, in its heaviest form, is suitable for measuring the brake drag on the largest commercial vehicles and buses.

In addition to measuring the total brake power, this type of machine gives independent readings at each wheel, and therefore indicates to the operator the condition of balance between the brakes on each axle and also the distribution between the axles themselves. The sum of the indicator readings divided by the total weight of the vehicle can be expressed as braking percentage.

Another type of the fixed-floor machine has four long checkered floor plates sunk flush with a drive-way, and with this type the vehicle is driven on to the plates and the brakes applied. Each of these plates is mounted on runners so that the plates are capable of movement, but movement is resisted by either calibrated springs or hydraulic cylinders. A pillar is mounted at one side of the runway, clear of the vehicle's track, and in the case of the spring-loaded runners is equipped with dials which indicate the brake force at each wheel as weighed by the springs.

As each individual test occupies a very short period of time, each indicator is fitted with a tell-tale which remains at the maximum figure recorded. In the hydraulic type, a column of liquid for each individual platform is forced up a calibrated tube and acts as a similar indicator. It will be evident that this type of brake-testing machine measures the brake drag at each tyre and gives similar readings to those obtained from the roller type.

Brake Testing on the Road

Brake testing on the road from any speed is usually carried out with the aid of an inertia instrument, and these can be generally classified into two types, both depending on inertia effects during speed change, but in one case the inertia of a mass mounted as a pendulum is used, while the other depends on the similar inertia of a column of liquid in a closed circuit of glass tubing. In both cases, application of the vehicle's brakes disturbs the attitude of repose of the pendulum or the column of liquid as in each

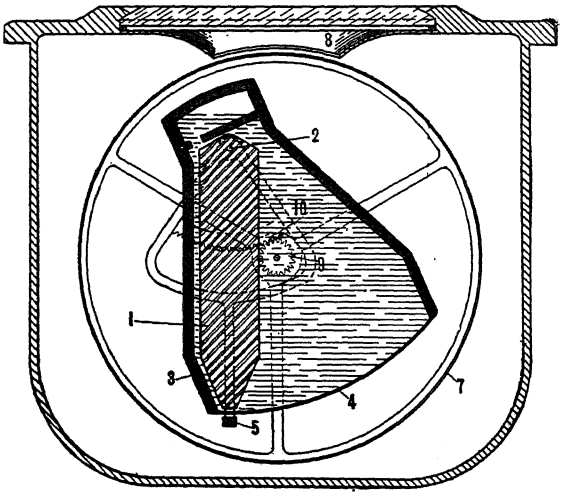


Fig. 3 (LEFT).—PRINCIPLE OF FERODO BRAKE TESTER

Showing permanent magnet pendulum 1, suspended on centre 2, and enclosed in sealed box 3 filled with suitable damping fluid. A light armature 5 is so arranged that by magnetic attraction from the magnetic pendulum it follows the movement of the pendulum. The movement of the armature is magnified and transferred to the revolving indicating scale 7 by means of toothed segment and pinion 10 and 9. The scale is seen through window 8. When the brake is applied the pendulum will take up a position corresponding to the rate of deceleration, which is therefore recorded on the scale. The scale retaining mechanism is not shown in the diagram.

case the free mass adopts a new position which depends directly on the rate at which speed changes.

A freely suspended pendulum in a vehicle which is either stationary or moving at constant speed will, of course, retain its normal vertical position, but during any change of speed the pendulum deflects from the vertical, and, providing the speed changes at constant rate, the rate of deceleration, or, for the matter of that, acceleration, is always correctly represented by the tangent of the angle to which the pendulum is deflected from the vertical.

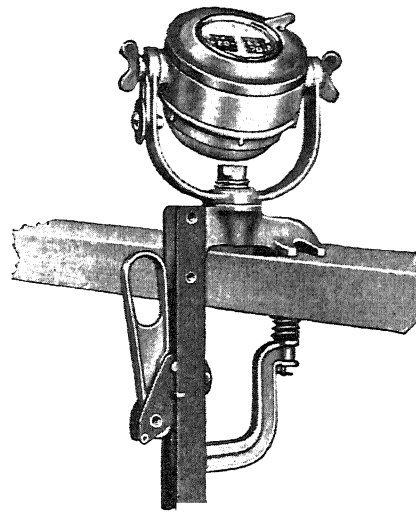


Fig. 4.—HOW FERODO BRAKE-TESTING METER IS MOUNTED ON RUNNING-BOARD OF CAR FOR A BRAKE TEST

Ferodo Brake-testing Meter

Perhaps the best-known instrument of this type is the Ferodo brake-testing meter (Figs. 2 and 3), which consists of a powerful permanent magnet suspended at one end on anti-friction bearings in a non-magnetic casing which is almost completely filled with a light damping liquid. The bottom end of this pendulum swings just clear of a thin brass diaphragm, and outside this diaphragm a light armature is suspended from co-axial pivots so that the armature follows every movement of the pendulum pole inside the casing. The armature is connected through instrument gearing to a cylindrical dial encircling the mechanism, and the calibration on the dial can be seen through a small window in the top of the instrument outer casing. The dial itself gives two separate readings, the left-hand one reading the equivalent stopping-distance at any particular rate of retardation from 20 m.p.h., and the right-hand scale giving the corresponding reading of brake performance or "efficiency." The meaning of this brake-performance figure expressed as a percentage has been explained earlier in this article.

Clamping the Ferodo Meter to the Car

The instrument has a universal mounting terminating in a quick-acting clamp, and all that is needed is to clamp it to some rigid portion of the vehicle and, with the vehicle standing on level ground and the instrument controlling lever in the free position, set the instrument so that the marks at the side of the window coincide with zero, or set level marking on the

TABLE I.—CORRESPONDING STOPPING DISTANCES AT DIFFERENT SPEEDS
(all measurements made on level road)

Brake Efficiency per cent. Meter Reading	*Distance to Stop in Feet*				
	From 20 *m.p.h.*	*From* 30 *m.p.h.*	*From* 40 *m.p.h.*	*From* 50 *m.p.h.*	*From* 60 *m.p.h.*
2	670	1510	2680	4170	6000
4	335	754	1340	2085	3000
6	224	503	894	1390	2000
8	168	377	670	1040	1500
10	134	302	536	833	1200
12	112	251	447	694	1000
14	96	215	383	595	857
16	84	189	336	521	750
18	74·5	167	298	463	667
20	67	151	268	417	600
22	61	137	244	379	545
24	56	126	224	347	500
26	51·5	116	206	321	462
28	48	108	192	298	428
30	44·7	100	178	278	400
32	41·8	94	168	261	375
34	39·4	88·5	158	245	353
36	37·2	83·6	149	231	334
38	35·3	79·5	141	219	316
40	33·5	75·4	134	208	300
42	31·9	71·8	128	198	286
44	30·5	68·5	122	190	273
46	29·2	65·6	117	181	261
48	28	62·8	112	173	250
50	26·8	60·3	107	167	240
52	25·8	58	103	160	231
54	24·8	55·8	99	154	222
56	24	53·8	96	149	214
58	23·1	52	92·4	144	207
60	22·4	50·2	89·3	139	200
62	21·6	48·6	86·4	134	194
64	21	47·2	83·7	130	188
66	20·3	45·7	81·2	126	182
68	19·7	44·4	78·8	123	176
70	19·2	43	76·6	119	171
72	18·6	41·9	74·4	116	167
74	18·1	40·7	72·4	113	162
76	17·7	39·7	70·6	110	158
78	17·2	38·7	68·7	107	154
80	16·8	37·7	67	104	150
82	16·3	36·8	65·2	102	146
84	16	35·9	63·7	99	143
86	15·6	35·1	62·3	97	139
88	15·2	34·3	60·8	95	136
90	14·9	33·5	59·6	93	133
92	14·6	32·8	58·3	91	130
94	14·3	32·1	57	89	128
96	14	31·4	55·8	87	125
98	13·7	30·8	54·7	85	122
100	13·4	30·2	53·6	83	120

TABLE II.—CORRESPONDING STOPPING TIMES

Brake Efficiency per cent. Meter Reading	*Time to Stop in Seconds*					*Rate of Retardation*	
	From 20 m.p.h.	*From 30 m.p.h.*	*From 40 m.p.h.*	*From 50 m.p.h.*	*From 60 m.p.h.*	*Feet per sec. per sec.*	*M.P.H. per sec.*
2	45·7	68·5	91·4	114	136	·64	·44
4	22·8	34·2	45·6	57	68	1·29	·88
6	15·3	23	30·6	38	46	1·93	1·32
8	11·4	17·2	22·9	28	34	2·57	1·76
10	9·1	13·7	18·3	23	27	3·22	2·2
12	7·6	11·5	15·3	19	23	3·86	2·64
14	6·6	9·8	13·1	16	20	4·5	3·08
16	5·7	8·6	11·5	14	17	5·15	3·52
18	5·1	7·6	10·2	13	15	5·8	3·96
20	4·6	6·8	9·1	11	14	6·44	4·4
22	4·2	6·2	8·3	10	12	7·08	4·84
24	3·8	5·7	7·6	9·5	11	7·72	5·28
26	3·5	5·3	7	8·8	11	8·36	5·72
28	3·3	4·9	6·5	8·1	9·8	9	6·16
30	3	4·6	6	7·6	9·1	9·65	6·6
32	2·9	4·3	5·7	7·1	8·5	10·3	7·04
34	2·7	4	5·4	6·7	8	10·9	7·47
36	2·5	3·8	5·1	6·3	7·6	11·6	7·92
38	2·4	3·6	4·8	6	7·2	12·2	8·36
40	2·3	3·4	4·6	5·7	6·8	12·9	8·8
42	2·2	3·3	4·4	5·4	6·5	13·5	9·24
44	2·1	3·1	4·2	5·2	6·2	14·2	9·67
46	2	3	4	4·9	5·9	14·8	10·1
48	1·9	2·9	3·8	4·7	5·7	15·5	10·56
50	1·8	2·7	3·7	4·6	5·5	16·1	11
52	1·8	2·6	3·5	4·4	5·3	16·8	11·45
54	1·7	2·5	3·4	4·2	5·1	17·4	11·9
56	1·6	2·5	3·3	4·1	4·9	18	12·3
58	1·6	2·4	3·2	3·9	4·7	18·7	12·8
60	1·5	2·3	3·1	3·8	4·6	19·3	13·2
62	1·5	2·2	3	3·7	4·4	20	13·6
64	1·4	2·1	2·9	3·6	4·3	20·6	14·1
66	1·4	2·1	2·8	3·5	4·1	21·2	14·5
68	1·3	2	2·7	3·3	4	21·9	15
70	1·3	2	2·6	3·2	3·9	22·5	15·4
72	1·3	1·9	2·5	3·2	3·8	23·2	15·8
74	1·2	1·9	2·5	3·1	3·7	23·8	16·3
76	1·2	1·8	2·4	3	3·6	24·4	16·7
78	1·2	1·8	2·3	2·9	3·5	25·1	17·2
80	1·1	1·7	2·3	2·8	3·4	25·7	17·6
82	1·1	1·7	2·2	2·8	3·3	26·4	18
84	1·1	1·6	2·2	2·7	3·2	27·1	18·5
86	1·1	1·6	2·1	2·6	3·2	27·7	18·9
88	1·1	1·6	2·1	2·6	3·1	28·3	19·4
90	1	1·5	2	2·5	3	29	19·8
92	1	1·5	2	2·5	3	29·6	20·2
94	1	1·5	2	2·4	2·9	30·2	20·7
96	1	1·4	1·9	2·4	2·8	30·9	21·1
98	·9	1·4	1·9	2·3	2·8	31·6	21·6
100	·9	1·4	1·8	2·3	2·7	32·2	22

rotating dial. The instrument is clamped in this position, and no connection is required with any part of the vehicle's mechanism.

Making the Road Test

In order to obtain a test reading, the instrument control is turned to "test," the vehicle driven up to any speed above 15 m.p.h., and the brakes applied. There is no need to observe the reading, as the scale is automatically held at the maximum obtained. The reading can therefore be noted after each individual brake application, and by turning the control to "free" and then back to "test," the dial is returned to zero and the instrument is ready to record another brake application. Generally speaking, brake testing is carried out on approximately level roads, but this type of inertia instrument can be equally satisfactorily used on a gradient, the instrument still recording correctly under such conditions.

Other Instruments

With regard to the similar inertia instruments arranged as a mass of liquid in glass tubing, the principle on which they operate is exactly similar to the pendulum type, but suffers under the disadvantage that the reading of the liquid level must be carried out during the actual brake application, and it is therefore almost impossible to use this type single-handed.

There are, of course, more elaborate types of instruments in use for road brake testing, but these are confined to the research departments of vehicle and brake-lining manufacturers and some technical institutions. These types of instruments frequently consist of a cycle wheel of accurately measured circumference mounted on a trailing arm which can be attached to the vehicle to be tested. A light drive is taken up this arm and serves to propel paper strip at a speed proportional to the vehicle's speed while a mark is made on the paper indicating the precise point at which the brakes were applied and a similar mark when the vehicle comes to rest—the distance between these marks represents the stopping-distance to a predetermined scale. This measurement would, of course, be useless without an accurate record of the initial speed, and this is obtained by time markings controlled from a scientifically accurate clock.

We are indebted to Messrs. Ferodo, Ltd., for the information upon which the above article is based.

THE BEDFORD CHASSIS

K, M, AND O MODELS

A SECTIONAL view of the rear axle and rear hub of Model K truck is shown in Fig. 1.

The axle housing is a built-up assembly consisting of large-diameter steel tubes pressed into a central differential carrier of cast steel, and located by dowels. (Side tubes cannot be serviced separately, owing to pressure required to press them into the differential carrier.)

The final drive consists of spiral bevel gears, the pinion being straddle-mounted between a single-row roller bearing at its inner end and a double-row ball bearing located between the pinion and the propeller-shaft coupling flange. Pinion adjustment is controlled by shims.

The pinion is offset $1\frac{7}{16}$ in. to the right-hand side of the chassis centre-line, in order to equalise the loading on the differential bearings, but the axle shafts are of equal length and interchangeable. A thrust-pad limits spiral-drive gear deflection under heavy loading.

The differential assembly is mounted between two ball bearings housed in the differential carrier and located by threaded locking rings.

In Model M, the axle housing, final drive, and differential assembly are similar to the K type, the main difference being that for the M-type rear axle the axle housing tubes are formed to support the wheel hub bearings.

The general design of Model O is similar to the M-type axle, but is of heavier construction to suit the wider track and higher loading. The pinion is offset $1\frac{1}{2}$ in. to the right-hand side of the chassis centre-line, and the differential assembly is mounted between tapered roller bearings.

Removal of Differential Assembly—Model K

To remove the differential case and spiral-drive gear assembly, the following operations must be carried out:

Jack up the rear of the vehicle and remove the wheels, hubs, and axle-shaft key.

Next remove the ten setscrews and lock washers which attach the pressed-steel oil deflector encircling the axle shafts to the axle casing.

Remove the " perfect " oil seal and bearing retaining plate, and withdraw the axle shaft complete with bearing.

Place an oil tray under the centre of the axle, then remove the nine setscrews and one nut and lock washer which attach the axle-housing cover, and remove the cover.

Mark the differential carrier caps to ensure that they are refitted to the same side.

Remove the four large bolts and lock washers which retain the differential carrier caps.

Remove the caps and lift out the differential case and spiral-drive gear assembly.

Removal of Differential Assembly—Models M and O

Jack up the rear of the vehicle for easy access.

Remove the ten nuts and lock washers at the outer extremity of each rear hub and draw out the axle shaft approximately 1 ft., so that the shaft clears the side gear splines.

The remaining operations involved in removing the differential cage and ring-gear assembly are the same as those already described for the K model.

ALL MODELS

To Replace Differential Assembly

Replacement of the differential assembly can be effected by reversing the operations given for removal, noting the following points :

The rear axle on the 3/4-ton and 5-ton models should always be refilled with an extreme-pressure lubricant.

Removal of Spiral-drive Pinion

Remove the differential case and spiral-drive gear assembly as previously described.

Disconnect the rear universal joint from the flange of the bevel pinion, and the hand-brake operating rods from the bell-crank lever end.

Remove the setscrews and the lock washers from the pinion cover. Then, by applying light blows with a lead hammer to the inner end of the pinion, drive out the pinion, together with the universal joint flange and the pinion cover and oil-seal assembly, towards the front end of the axle casing.

To Replace Spiral-drive Pinion

Reverse the operations given for removal, particularly noting the following points :

The correct shimming of the pinion is imperative. Therefore, providing no parts have been renewed, the same number of paper shims between the front cover and the differential carrier face and the metal shims at the rear of the thrust-bearing outer race must be replaced as removed.

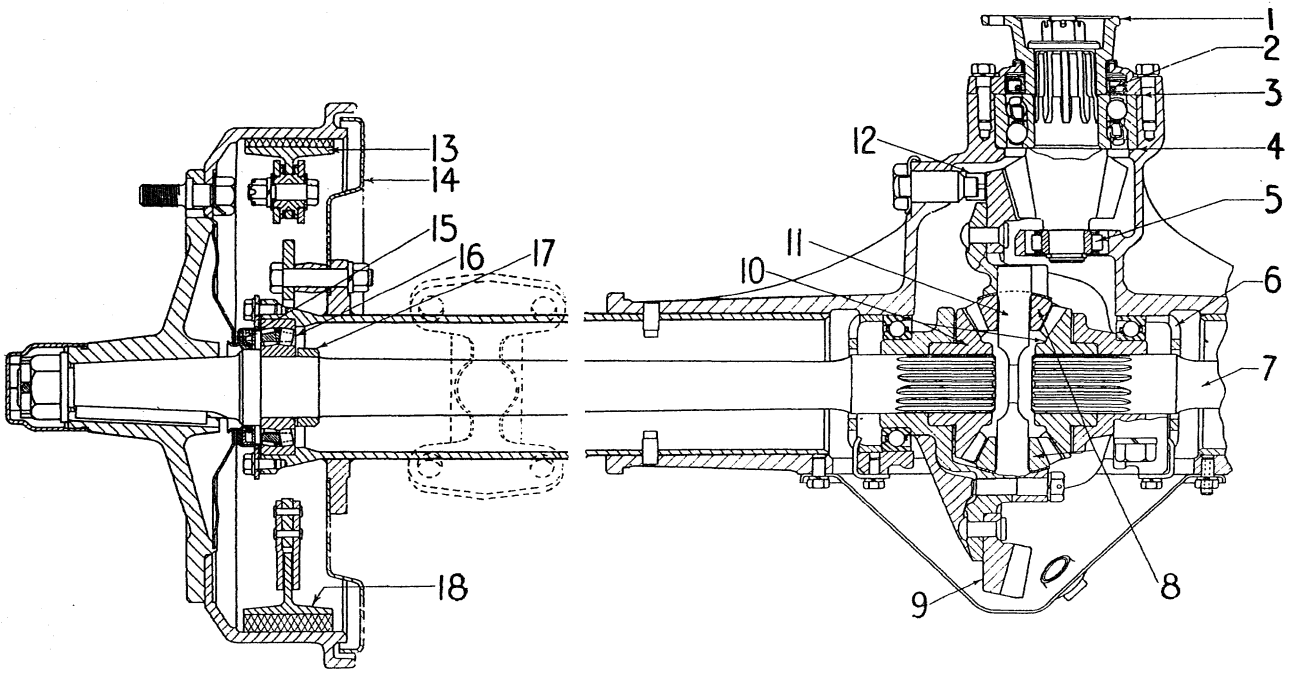


Fig. 1.—Sectional view of rear axle and rear hub—model K

1. Universal joint flange.
2. Oil seal.
3. Pinion adjustment washers.
4. Pinion adjustment washers.
5. Pinion support bearing.
6. Crown wheel adjusting ring.
7. Axle shaft.
8. Planet wheel.
9. Crown wheel.
10. Sun wheels.
11. Planet pinion spindle.
12. Crown wheel thrust pad.
13. Brake shoe.
14. Brake flange plate.
15. Oil seal.
16. Hub bearing.
17. Bearing locking ring.
18. Brake shoe.

These shims are ·005 in. and ·010 in. in thickness, and it is always necessary to insert paper shims between the front cover and the differential-carrier front face to a thickness of ·010 in. more than the thickness of the metal shims. This allows for compression of the paper shims and ensures an effective oil seal.

Removal of Rear-Axle Assembly Complete

Jack up the rear of the vehicle and remove the road wheels. Disconnect the rear universal joint from the flange of the bevel pinion.

Disconnect the hydraulic-brake flexible tube at the point of connection to the copper tubing, which runs from a bracket bolted to the chassis side member to the union on the Lockheed servo unit master cylinder.

Disconnect the hand-brake cable from the bell-crank lever by slackening the locknut and removing the setscrew which secures the "eye" end of the cable to the bell-crank-lever ball.

Place a jack underneath the centre of the axle, so as to carry the weight of the axle assembly, and remove the U-bolt nuts and the U-bolts. Lower the axle on the jack sufficiently to allow the jack, together with the axle, to be drawn out from under the vehicle.

To Replace Rear Axle

Replacement of the rear axle can be effected by reversing the operations given for removal, noting the following points.

It is essential that the master cylinder of the brake system is topped up, and that bleeding of the brake system is carried out as required by Lockheed hydraulic brakes provided with vacuum servo cylinder assistance.

The rear axle on the $\frac{3}{4}$-ton and 5-ton models should always be refilled with an extreme-pressure lubricant.

Spiral-drive Gear

When it becomes necessary to fit a new spiral-drive gear, it is necessary to warm the gear on a hot-plate just sufficiently to allow it to be dropped into position on the differential cage register. Before the gear is allowed to cool down, the rivet holes must be lined up and the gear bolted into position on the cage in four places, so that the riveting can be carried out. Cold rivets must be used.

The backlash between the spiral-drive pinion and the spiral-drive gear should be not less than ·006 in. and not more than ·010 in.

BRAKES

Lockheed hydraulic brakes, employing a tandem master cylinder which prevents any possibility of complete foot-brake failure in the event of leakage from front or rear pipe lines, are fitted on all models.

With the exception of the model K, which is not provided with servo

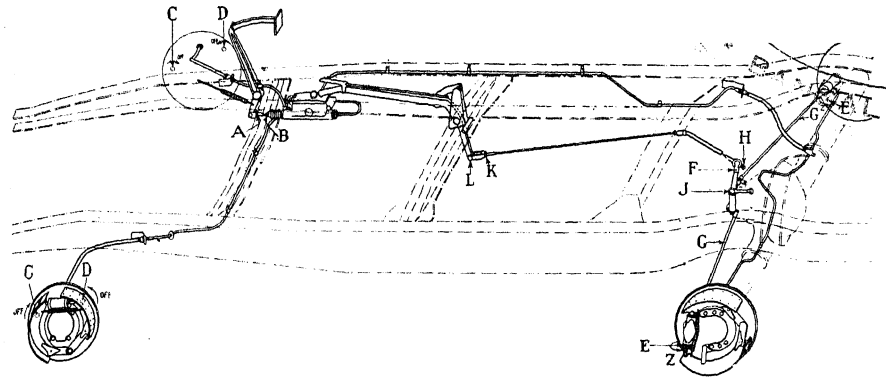


Fig. 2.—BRAKE ADJUSTMENT CHART—MODEL K

assistance, the vacuum servo cylinder is mounted as a unit with the Lockheed cylinder, and is coupled by means of enclosed linkage forming part of the combined assembly. The Lockheed-servo unit assembly is bolted to the chassis frame just behind the foot-brake pedal.

On the front brakes the wheel cylinders are enclosed by the brake drum in a conventional manner, as on other Lockheed systems; the rear-wheel cylinders, however, are mounted externally to obtain maximum cooling.

Particulars of Lockheed and Lockheed-servo brake systems will be found in Vol. I, pp. 284–304.

Foot-brake Adjustment

Each front-brake shoe is provided with a cam-type adjuster operated from the outside of the brake backplate by a hexagon-headed bolt (*see* Figs. 2 and 3).

Jack up the front wheel and turn the cam nuts *C* & *D* to the fully "off" position. Then turn the cam nut *C* in the direction of the arrow, until the front-brake shoe rubs slightly on the inside of the drum. Slacken back sufficiently to ensure that the drums are perfectly free.

Repeat the operation with the rear-cam nut.

It is very important that each front wheel rotates freely without the slightest drag following adjustment.

To adjust the rear brakes, jack up the rear wheels, making certain that the hand-brake lever is in the fully "off" position. Remove the rubber flaps underneath the wheel cylinder, which gives access to the brake-shoe adjusting wheel. Turn the adjusting wheel *E* in the direction of arrow *Z* until it is not possible to turn it any farther.

Apply heavy pressure to the foot-brake pedal, to centralise the shoes in relation to the drums. (This centralisation is automatic through the

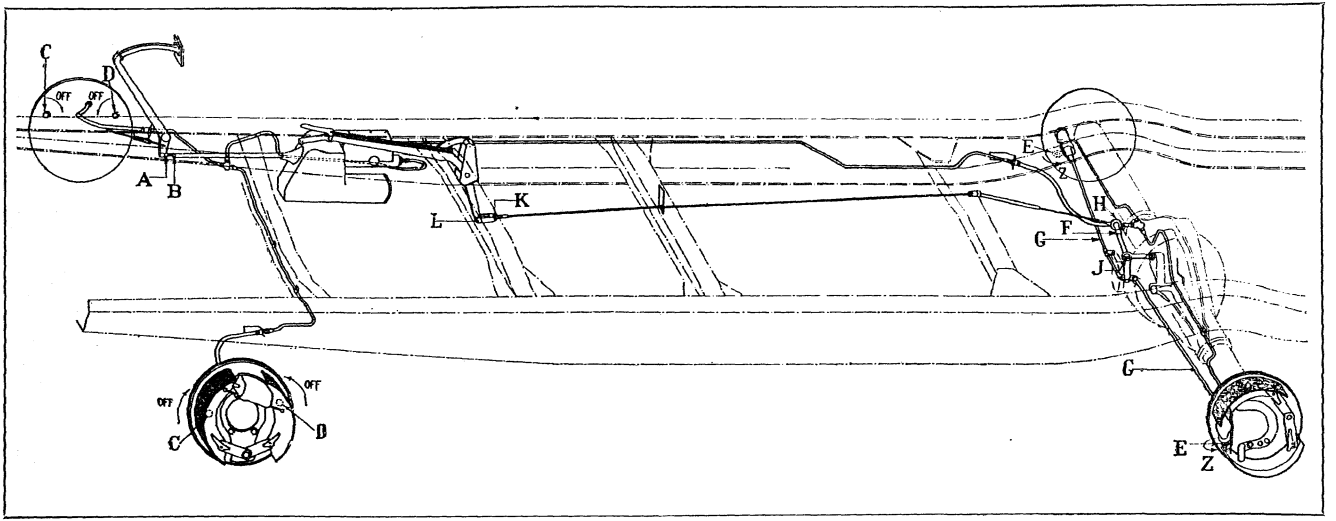


Fig. 3.—BRAKE ADJUSTMENT CHART—MODELS M AND O

A. Clevis pin.
B. Locknut.
C. and D. Cam nuts.
E. Adjusting wheel.
F. Lever.
G. Hand-brake side rods.
H. Setscrew.
J. Bell-crank-lever fulcrum pin steady.
K. Locknut.
L. Clevis pin.

bisector, for particulars of which *see* Vol. I, p. 242). Again turn the adjusting wheel as far as possible. Slacken the adjustment back approximately three notches, or until the road wheels rotate freely.

Always replace the rubber flaps.

Hand-brake Adjustment

Do not attempt to adjust the hand-brake independently. The adjustment for the rear-brake shoes given under "Foot-brake Adjustment" serves for both foot-brake and hand-brake adjustment, unless any part of the hand-brake mechanism has been dismantled.

Except in the case of accident or previous incorrect setting, the hand-brake mechanism should not be disturbed. Should cases arise, however, where resetting is necessary, proceed as follows, with reference to Figs. 2 and 3.

Release the hand-brake lever to the fully "off" position, and remove the clevis pins (one at either end) from the hand-brake side rods *G*. Remove the rubber flap which gives access to the adjusting wheel, and tighten the wheel *E* as far as possible.

Slacken back the locknut on the bell-crank-lever fulcrum pin steady *J*, and affix the bell-crank lever setting bracket. Slacken the locknut at the wheel-cylinder end of the hand-brake side rods, and adjust the rods so that the clevis pins securing the rods to the bell-crank-lever mechanism may be inserted. Tighten up the hand-brake side rod locknuts.

Next slacken back the locknut *K*. Remove the clevis pin *L* and adjust the clevis end until the slack in the cable is equal to two-thirds of the diameter of the clevis-pin hole.

Replace the clevis pin and tighten the locknut. Make certain that setscrew *H* is seating in ball end of lever *F*.

Adjust the rear-brake shoes as described under "Foot-brake Adjustment." Remove the bell-crank-lever setting bracket and thoroughly tighten the locknut on the bell-crank-lever fulcrum pin steady *J*.

Foot-brake-pedal Adjustment

It is important that the foot-brake pedal has $\frac{1}{4}$-in. free movement. To adjust the pedal for clearance, slacken back locknut *B*, remove the clevis pin at the front end of rod *A*, and turn the yoke end until the requisite clearance is obtained. Replace clevis pin and tighten locknut *B*.

JCV 10/12-CWT. VAN

The design of the JCV 10/12 independent front-wheel suspension is as follows:

The torsion shaft and tube assembly, which constitutes the main front-spring component, interacts with a pre-compressed coil spring

acting upon a toggle lever, and double-acting hydraulic shock absorbers which eliminate road shocks in both the bump and rebound direction.

Servicing procedure for a similar system of independent front-wheel suspension is described in Vol. III, pp. 62–70, under the heading "Vauxhall Independent Suspension Systems."

Front-end Height

To check the standing height of the front of the vehicle without dismantling, measure the distance from the bottom edge of the brake-flange plate to the head of the foremost bolt attaching the rebound bumper bracket to the steering knuckle. This dimension should be $1\frac{11}{32}$ in. plus or minus $\frac{3}{16}$ in.

If readjustment is necessary, proceed as described below.

In order to remove the torsion shaft and tube assembly from the housing without effort, it is necessary to adjust the position of the carrier arm so that there is no torsion (or twist) in the shaft and tube. Remove the rebound bumper and bracket and affix Britool Jig No. 899 to the bottom of the spring housing, then turn the adjusting screw until the distance between the edge of the jig farthest away from the carrier arm and the face of the web against which the adjusting screw contacts measures $1\frac{3}{4}$ in. plus or minus $\frac{1}{8}$ in. This brings the carrier arm to the no-torsion position.

Adjustment of Vehicle Front-end Height

Whenever a torsion shaft and tube assembly has been fitted, a check should be made to determine whether the front of the car is standing at its correct height.

With a weight equivalent to two persons 10–12 st. in weight in the front compartment of the vehicle, measure the distance from the bottom edge of Britool Jig. No. 899 to the bottom edge of the brake-flange plate. This should be $2\frac{1}{2}$ in. plus or minus $\frac{1}{8}$ in.

When checking the above measurement, slacken well back the jig-adjusting screw, and bounce the front of the vehicle lightly to ensure that friction in the suspension units is not giving a false reading.

It is possible that the measurement may not come within these limits, and in view of this a vernier adjustment is provided by the relationship between the splines in the torsion shaft and the holes in the torsion-tube flange, there being forty-nine and eight respectively.

If the vehicle is too low on the side that has been disturbed, it must be raised once more and the nuts and lock washers removed from the flange-retaining studs. Bring the carrier arm to the "No-torsion" position, and extract torsion-shaft assembly clear of the splines.

Rotate the tube nearly one-eighth of a turn (six splines on the shaft) in the required direction, according to which unit is being treated.

Note Carefully: To raise the front of the vehicle, the torsion-shaft assembly must be rotated in a clockwise direction for the nearside unit

and in an anti-clockwise direction for the offside unit when facing the flange of the assembly concerned. To lower, turn the torsion-shaft assembly in the reverse direction.

Push the shaft gently into the beginning of the splines and tighten the jig-adjusting screw until the holes in the flange of the torsion tube line up with the studs, when the tube can then be pushed right home. *Do not use force during this operation.*

Lower the vehicle and check the dimension to see that front-end height is correct.

If the vehicle is too high on one side, bring the carrier arm to the "No-torsion" position. Turn the tube assembly nearly one-eighth of a turn (six splines on the shaft) in the reverse direction to that for raising the front of the vehicle, push the torsion shaft into the beginning of the splines, and slacken the jig-adjusting screw until the holes in the flange of the tube line up with the studs of the housing. The torsion shaft and the tube assembly should then be pushed right home.

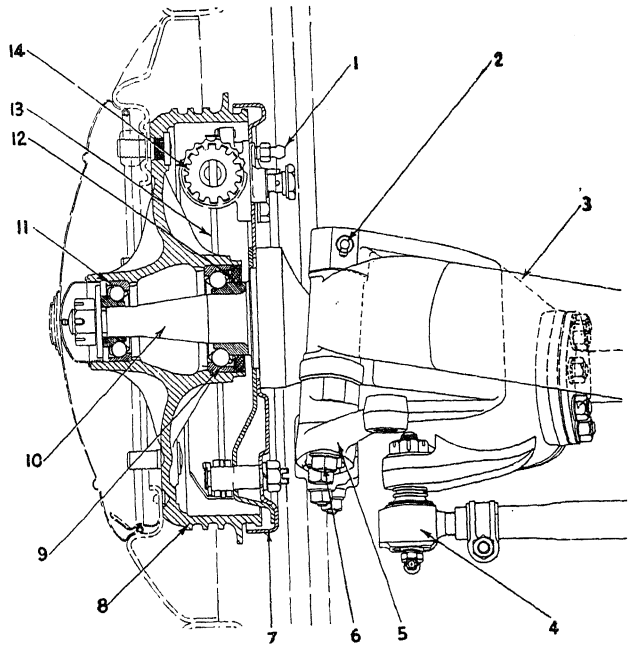


Fig. 4.—SECTIONED FRONT HUB AND BRAKE GEAR

1 Hydraulic brake bleeder.
Pivot pin lubrication nipple.
3 Pivot pin support member (front axle).
4. Tie road joint.
5. Steering arm.
6. Steering arm foremost bolt.
7. Brake flange plate.
8. Brake drum.
9. Front hub ball race (inner).
10. Wheel carrier arm stub axle.
11. Front hub ball race (outer).
12. Oil seal assembly.
13. Front brake shoe.
14. Brake adjusting screw.

Having obtained the correct adjustment for height, remove the jig, replace the steering arm or rebound bumper bracket, lower the vehicle, and replace and tighten the nuts and washers which secure the tube flange.

Refill units with fresh shock-absorber oil.

Steering Arm and Connections

The pivot-pin bronze bushes are fully floating, and a ball thrust-bearing is interposed between the lower face of the pivot-pin boss of the axle beam and the steering knuckle. Lift of the steering knuckle is controlled to provide a clearance of ·003 in. maximum, by shims ·005 in. and ·010 in. thick which are fitted on the upper face of the pivot-pin boss.

The self-adjusting spring-loaded ball joints are serviced only as complete assemblies. In the event of excessive wear taking place, it will be necessary to renew the whole assembly.

Removal and Replacement of Steering Joints

To remove the ball joint for renewal, remove the cotter pin and partly unscrew the nut which secures the ball joint, then, by lightly tapping the nut with a copper hammer, the tapered shank portion of the ball joint can be driven out.

Slacken off the clamp-bolt which secures the ball joint to either the tie-rod or connecting rod, and unscrew the ball joint from the threaded end of the rod.

To replace, reverse the operations given for removal.

Front-wheel Alignment

Front-wheel alignment is measured in the usual way at the wheel rims, in line with the centre of the hubs, and with the wheel straight ahead it should be noted that there is *no* " toe-in " allowance. To enable this condition to be maintained, adjustment is provided at each end of the tie-rod by means of right-hand and left-hand threads, screwing into the tie-rod ends.

Adjustment for End Float in Steering-worm Shaft

The adjusting nut of the ball race controlling end float of the worm shaft is integral with the top cone of the bearing, and is secured by a locknut.

With the front of the vehicle jacked up, the adjusting nut should be tightened down gently, until a slight load is felt on the steering wheel when turned, after which the adjusting nut should be slackened back slightly until the steering wheel feels free. Finally, holding the adjusting nut in position, retighten the locknut.

Propeller Shaft and Universal Joints

The drive is transmitted from the gearbox to the rear axle by an open tubular propeller shaft, embodying two Hardy Spicer needle-roller-type universal joints. These joints are packed with special non-separating grease and require no further attention. An oil-gun nipple is provided for lubricating the splines at the forward end of the shaft.

The universal joints at each end of the shaft are attached by four

high-tensile steel bolts, slotted nuts, and split-pins to coupling flanges fixed respectively to the rear of the gearbox mainshaft and the forward end of the bevel-pinion shaft.

To Remove and Replace

The removal and replacement of the shaft entails the removal and replacement of the eight bolts and nuts mentioned above.

If for any reason the front universal joint is removed from the splines of the propeller shaft, it is essential that the joint is replaced to give correct relationship with the rear universal joint. This is obtained by lining up the lugs of the *flanged* yoke on the front universal joint with the lugs of the *flanged* yoke on the rear universal joint.

This position is also indicated by two arrow marks pointing towards each other and in line, one being on the main body of the propeller shaft near the splined end, and the other on the outside of the splined portion of the front universal joint.

Rear Axle

The rear axle is of the semi-floating type, having spiral-bevel final drive gears. The differential is slightly offset, and necessitates the use of axle shafts of different lengths ; consequently the right- and left-hand shafts are not interchangeable.

For additional information on the repair of this type of axle, the reader is referred to " Repair Notes on Vauxhall Cars," p. 169, Vol. III.

Removing Differential Carrier Assembly from Vehicle

To remove the differential carrier assembly from the vehicle, the following operations must be performed :

Having jacked up the vehicle sufficiently high for the rear wheels to clear the ground, remove the wheels and hubs. Provision is made for a hub drag by means of an external thread on the centre boss of the hub.

Disconnect the hydraulic-brake pipe line at the unions on each rear-brake flange plate, and remove the four bolts which secure each flange plate to the rear-axle casing. Lift away the flange plates as far as is allowed by the movement of the hand-brake cable, and place by the side of the vehicle.

The axle shafts can now be withdrawn sufficiently to clear the splines in the side gears of the differential assembly.

Remove the four bolts and slotted nuts securing the rear univeral joint of the propeller shaft to the flange of the differential unit.

Release the eight nuts which secure the differential assembly to the rear-axle casing, and lift away the assembly, taking care not to damage the threads of the securing studs retained in the rear-axle casing.

Removing Rear-axle Assembly Complete from Vehicle

To remove the rear-axle assembly complete from the vehicle, a sequence of operations slightly different from those previously described will have to be undertaken.

Jack up the rear of the vehicle and remove the road wheels.

Disconnect the rear universal joint of the propeller shaft from the flange of the differential unit.

Disconnect the hydraulic-brake pipe line at the front end of the flexible tube which carries the brake fluid from the end of the copper tubing underneath the body to the copper tubing slipped to the back-axle casing.

Remove the hand-brake cable outer casings from the securing clips on the chassis frame.

Remove the two hand-brake cables from the hand-brake relay lever by releasing the single clevis pin which secures the two cable-yoke ends to the lever. Unscrew the nuts from the four U-bolts connecting the rear axle to the springs, and remove the U-bolts.

The axle is now free and can be lifted out sideways over the springs, taking care not to damage the brake flange plates.

Footbrake Adjustment

As wear occurs on the brake linings the amount of travel on the foot pedal increases, until the pedal will be forced nearly to the floorboards on heavy application of the brakes. When this occurs the shoes should be expanded by adjusting the sleeves *D*.

Jack up each wheel in turn and, with a screwdriver, remove the wheel-hub cover. This will reveal a hole in each brake drum which gives access to the adjusting sleeves *D*.

Using a screwdriver against the serrations, turn the right-hand sleeve (as viewed by the operator) of each brake upwards until the shoe just touches the drum, then back off four notches.

Turn the left-hand sleeve (as viewed by the operator) downwards until the shoe touches the drum, and then back off four notches, as in the previous case.

Hand-brake Adjustment

Whenever the rear-brake shoes are adjusted, the handbrake should be checked for operation and adjusted to suit.

Do not adjust the hand-brake without first taking up the adjusting sleeves D *of the rear brakes.*

Having taken up the adjusting sleeves *D* of the rear brakes, slacken off the locknut which secures the clevis end *A* at the end of the hand-brake primary cable. Remove the clevis pin from the clevis end and relay lever, and screw the clevis end along the thread until, with the clevis pin temporarily inserted, the hand-brake lever can be pulled on four notches without using undue force.

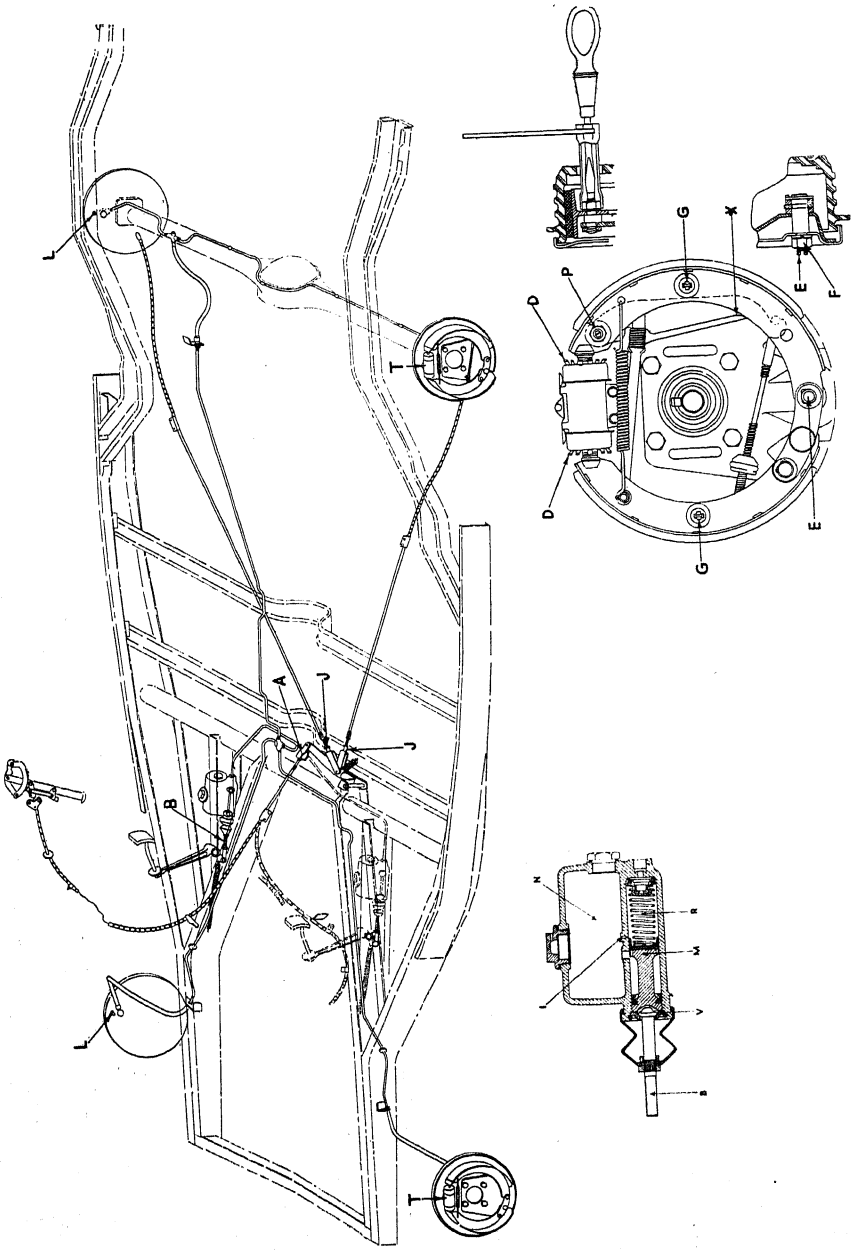


Fig. 5.—BRAKE ADJUSTMENT CHART—JCV MODEL

Re-insert the split-cotter in the clevis pin, and retighten the locknut which secures the clevis end *A*.

If the braking is uneven when the hand-brake is applied, balance of the brakes can be obtained by releasing the locknuts which secure the adjusting sleeves *J* on the hand-brake rear cables. Adjust the sleeves *J* until equal braking is obtained on both wheels, and securely tighten the locknuts retaining the sleeves *J* in position.

Finally release the hand-brake lever to the fully " off " position and, with the rear of the vehicle still jacked up, rotate the rear wheels to ensure that the brakes are not rubbing.

Hand-brake Adjustment after Mileage

After considerable mileage, the hand-brake operating lever in the rear hub will reach the limit of its travel, necessitating attention to an additional hand-brake adjustment inside the rear hub. To carry out this adjustment, jack up the rear of the vehicle and remove the rear wheels. Release the hand-brake lever to its fully " off " position.

Slacken the clevis end *A* of the hand-brake primary cable, also the cable-adjusting sleeves *J*. Adjust the clevis end *A* until the centre of the clevis pin is $8\frac{1}{4}$ in. from the centre of the tubular cross-member, when the relay lever is pulled to the rear of the vehicle, to take up any slackness.

Adjust the sleeves *J* on the hand-brake rear cables so as to take out any excessive slackness, and then pull the hand-brake lever on four notches.

Slacken off the locknut *P* in each rear hub, using the box spanner provided in the tool-kit. Insert a screwdriver down the centre of the box spanner into the slot provided, and rotate each bolt until the brake show makes contact with the drum, and a heavy drag is felt when turning each rear drum.

Tighten the locknuts *P*, and replace the wheels and hub covers. If the braking is uneven when the hand-brake is applied, balance of the brakes can be obtained by releasing the locknuts which secure the adjusting sleeves *J* on the hand-brake rear cables. Adjust the sleeves *J* (letting out the cable of the brake which binds hardest) until equal braking is obtained on both rear wheels. Retighten the locknuts.

The hand-brake operating cables are provided with greasers and should be lubricated every four thousand miles.

The hand-brake rear cables should be adjusted only for the purpose of balancing the rear brake after the major operation has been carried out, and *not* for taking up the adjustment.

Removal of Brake Shoes

When it becomes necessary to remove the brake shoes for examination or relining, this may be done without disturbing any part of the fluid system, the procedure being as follows :

Jack up the vehicle and remove the road wheels ; remove the combined hub and brake drum if dealing with the front brake, or in the case of the rear brake, remove the hub and drum from the taper of the axle shaft.

N.B.—Whenever a brake drum is removed for any reason, or a brake-shoe return spring is disconnected, care must be taken that the brake pedal is not depressed, as this would cause the pistons of the partially dismantled brake to be forced out of the cylinders, with the result that fluid will be lost, necessitating bleeding the system.

Disconnect the brake-shoe return spring and remove the shoe-guide springs and cups *G* by depressing the latter, and turning through an angle of 90°. Prise up and remove the lock washer from the pivot pin *E*, when the two brake shoes, together with the servo links attached to the leading shoe, can be removed.

In the case of the rear brakes, an additional operation is required. The nut *P* must be removed, thus releasing the trailing shoe from the hand-brake operating lever, which may be left in position.

N.B.—With the shoes removed one vitally important point must be realised before relining is undertaken. The balance of the brakes is dependent solely upon the coefficient of friction between the brake lining and brake drum, and since the fluid method of operation allows full compensation, it is essential that the same lining material be used for each brake shoe. Under no circumstances allow the linings to come in contact with oil or grease. Do not even touch the friction surface with the hands. Do not alter the existing chamfer at the ends of the linings.

Failure to comply with these instructions will lead to persistent trouble due to unbalanced braking.

The operations involved in relining the shoes follow the usual practice, but every care must be taken not to get grease on the friction surface.

Brake-shoe Reassembly

When refitting the brake shoes the sequence of operations is reversed, and the brakes reset as described on p. 506 under "Footbrake Adjustment."

Resetting the Brake System

Except in the case of accident or due to previous incorrect setting, the brake system should not be disturbed, but should cases arise where resetting is necessary, proceed as follows :

Adjust the foot-pedal push-rod *B* by slackening the locknut and adjusting the push-rod, so that there is $\frac{1}{2}$ in. free movement at the foot-brake pedal when it is in the fully "off" position, afterwards tightening the locknut which secures the push-rod.

This clearance or free travel is essential in order to allow the piston *M* in the master cylinder to return fully against its stop *V* and uncover the by-pass port *I*. If the return of the pedal is restricted, resulting in the

by-pass port being covered by the piston, the brakes will not release properly.

Set the hand-brake lever in the fully "off" position. Jack up the wheels and set the adjusting sleeves *D* to bring the brake shoes as close to the drums as possible. Adjust the hand-brake primary and rear cables to give the dimension of $8\frac{1}{4}$ in. between the clevis pin of the relay lever and the centre of the tubular cross-member, as described, taking care to ensure that the brake drums are not rubbing on the liners when adjustment is completed.

ADAPTING EXISTING BODYWORK FOR EMERGENCY USE

By H. J. BUTLER

CAREFUL attention to repairs and overhauling is of particular importance in war-time, because by this means the useful life of existing vehicles, which are difficult to replace, is extended. Also, vehicles, both new and already in service, are required to carry a different kind of load from that for which they were first designed. Consequently these vehicles require some structural alteration, or additional equipment, in order that they may be better adapted for the new condition of service.

Alterations to Bodywork

This emergency aspect of repair work consists chiefly of alterations to the bodywork, and ranges from a simple extension of the sides of a lorry up to the conversion of a luxuriously appointed coach into a capacious delivery van.

Using Old Yet Sound Material

In all such conversion jobs, economy of material should be carefully studied, because not only is the supply controlled and deliveries often delayed, but it is also more expensive than formerly. When new timber is not available, use should be made of the sound timber of second-hand bodywork. Timber does not deteriorate with age if it has been well protected by paint or other preservative. For similar reasons, the ironing up and panelling of the body may often be partly accomplished with material from an old body.

INCREASING HEIGHT OF LORRY SIDES

A drop-sided lorry may be required to carry farm produce or other bulky load, and its capacity must be increased. This may be done in various ways. The height of the body sides is approximately doubled by means of a superstructure consisting of uprights made from 3-in. by 1-in. deal battens. On the inside of these uprights are screwed lengthwise battens of 3-in. by $\frac{3}{4}$-in. deal, except for the bottom batten, which is 5 in. wide. This batten rests on top of the body side, as shown in Fig. 1.

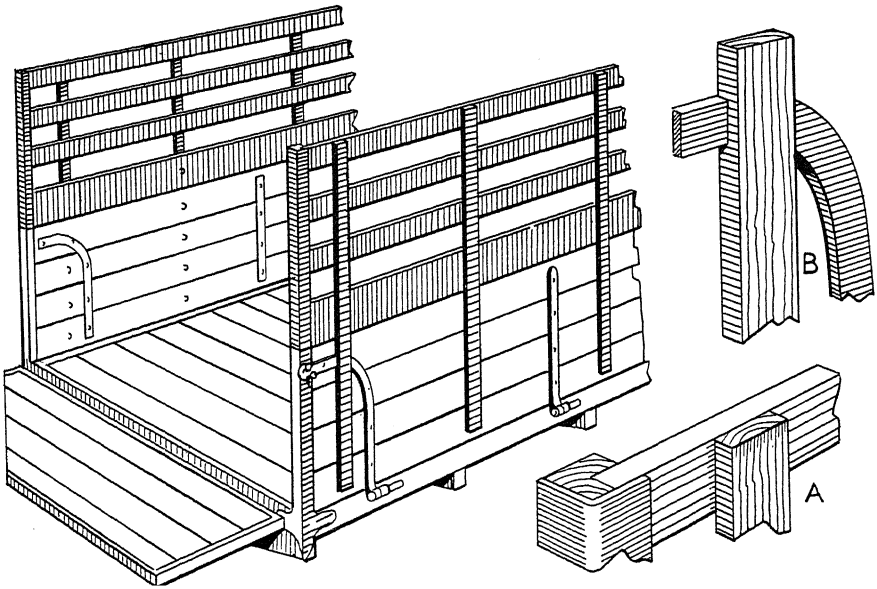


Fig. 1.—DROP-SIDED LORRY WITH THE HEIGHT OF THE SIDES INCREASED

A. End of lengthwise slat let into wood-filled angle-iron post. B. End upright recessed at the back for passage of hinge iron.

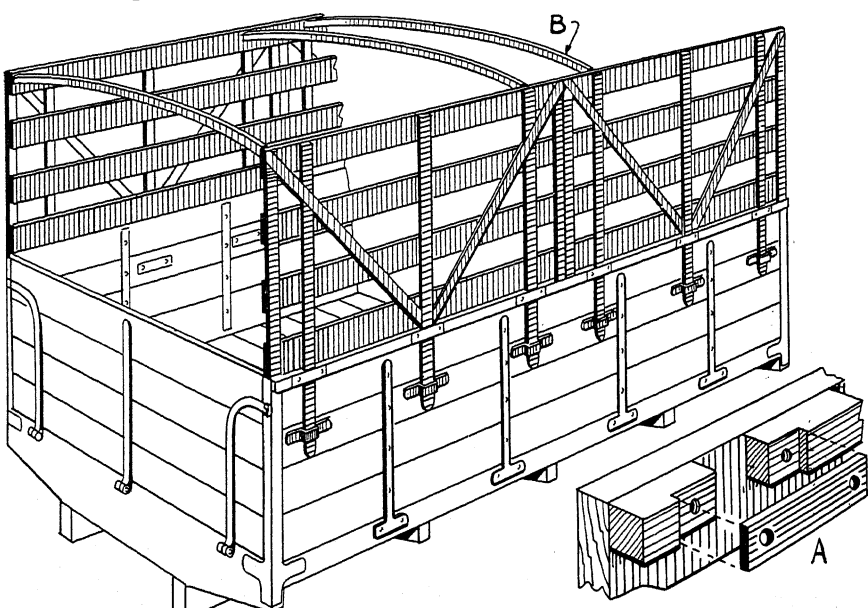


Fig. 2.—FIXED-SIDED LORRY INCREASED IN HEIGHT

Repairs to the Top Board

If the lorry has been in service some time, the top board of the drop-side may be worn, especially if it is not protected by a half-round or channel-section wearing plate. If badly worn or split, it should be renewed. The board is removed by releasing it from the top bolts which pass through the hinge-iron and the corresponding inside plate of $\frac{1}{8}$-in. mild steel, which provides a firm foundation against which the heads of the bolts are tightened.

Hind-corner Stanchions

The lorry usually has hind-corner stanchions, the feet of which are secured to the bottom frame of the lorry. The stanchion also provides a means of securing the tailboard and drop-side independently of one another. If there are no rear stanchions, then the opportunity should be taken to fit them, because they will add considerably to the life of the lorry; they may be purchased ready for fixing from a supplier of body fittings such as Messrs. Stedall & Co., 164 High Holborn, London, W.C.1.

End Posts

Assuming that the stanchions are in position, the slatted superstructure is completed by the addition of end posts which form as closely as possible an upright extension of the stanchions (Fig. 1). The end posts may be of angle-iron, and drilled so that the ends of the lengthwise slats may be screwed to them after a wood filling-piece has been inserted and recessed for the end of the slat (Fig. 1A).

If angle-iron is not available, then the end posts may be of hardwood, such as ash or oak, which is recessed to take the full substance of the lengthwise batten.

Fixing the Superstructure

The superstructure is attached by bolting the uprights to the drop-side, with the heads of the bolts and a washer under them on the inside of the body. The end uprights will probably have to cross the adjacent hinge-iron and, in order to ensure a flat bearing, the upright is recessed for the passage of the iron (Fig. 1B).

Detachable Loading-racks

Another method of increasing the height of the lorry sides includes the fitting of detachable loading-racks or frames. By this means, the high sides may be confined to the front part of the body, or all the loading-racks may be removed when only a normal height of body is required. These racks may be used either with a drop- or a fixed-sided lorry, as shown in Fig. 2.

Loading-rack Parts

A lorry up to 7 ft. 6 in. long may have two racks each side, three racks up to 10 ft. 6 in., and four racks for longer vehicles. Each rack consists of

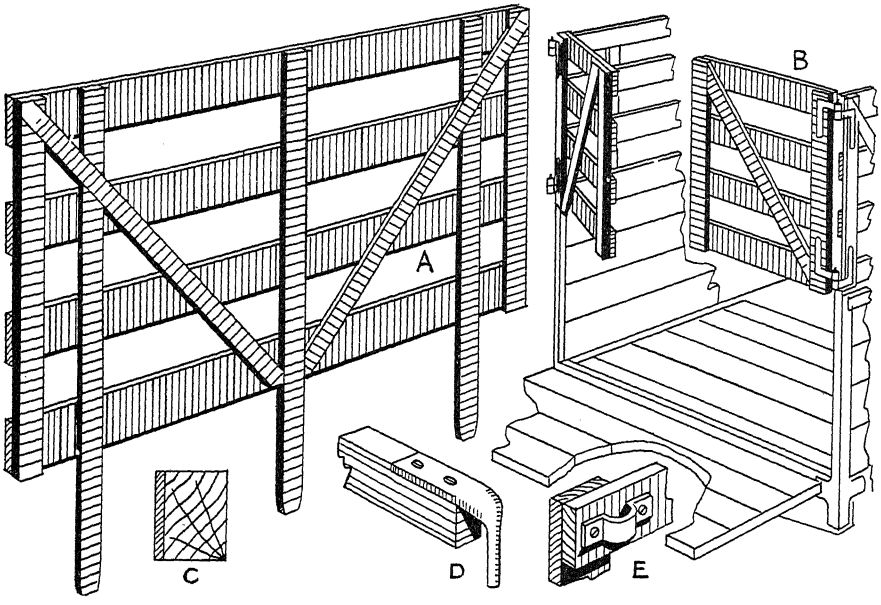


Fig. 3.—A. LOADING-RACK, AS FITTED TO THE LORRY SHOWN IN FIG. 2. B. END GATE ON LIFT-OFF HINGES. C. SECTION OF FLITCH-PLATED SPREADER (*see* FIG. 2B). D. HOOK PLATE OF SPREADER. E. STAPLE ENGAGING WITH HOOK PLATE

similar material to that already mentioned for the drop-sided lorry (Fig. 1), except that the end vertical batten is of similar material to the uprights. The whole is stiffened by means of a pair of diagonal braces of 2-in. by $\frac{3}{4}$-in. deal which are half-lapped across the uprights and end vertical battens.

Supporting the Rack

The uprights are made about 9 in. longer than the body of the rack, so that the feet so formed may pass through upper and lower staples. Instead of an upper staple the top of the lorry side may be reinforced with an outer hardwood rail made from $1\frac{1}{4}$-in. hardwood. This rail is temporarily fixed to the body, and then marked at the rack-upright positions. It is also marked for the recessing of a front plate $5\frac{1}{2}$ in. by $\frac{1}{4}$ in. thick so that, when the wooden rail is cut into sections and replaced on the body, the spaces between these sections form openings for inserting the uprights of the rack, while the front plate, when screwed in place, holds the upright securely in the upper position (Fig. 2A). The staples should be bolted to inside plates of $\frac{1}{8}$-in. iron.

Higher Tailboard

If it is desired to increase the height of the tailboard so that it is as high as the sides, then a loading-frame may be stapled to the tailboard and

opens with it. This extra height of tailboard is apt to be an obstruction when loading if it does not drop clear of the ground. If resting on the ground at an angle, it is easily broken.

Hinged Racks or Gates

The better method of increasing the height of the body at the back is to hang a pair of hinged racks or gates on the ends of the side racks. These end gates are then independent of the opening of the tailboard, although they have a projecting bottom lip plate which bears against the tailboard when it is closed (Fig. 3B). The gates are hung on lift-off hinges so that they are easily removed when necessary. Although the side loading-racks have sufficient rigidity to withstand the normal side thrust of the load, yet a considerable amount of leverage is thus exerted on the sides of the lorry.

Top Spreaders

To compensate for this, top spreaders (Fig. 2B) connect the off- and nearside frames, while at the same time a support is provided for a waterproof sheet. The spreader is curved and, if it has a moderate camber of not more than 3 in. in a length of 6 ft., it may be cut out from a $1\frac{1}{4}$-in. ash plank, and no steam bending is required. The spreader is reinforced on one side with a flitch plate of $\frac{1}{8}$-in. mild steel (Fig. 3C), and has a hook plate (Fig. 3D) at each end which registers with a staple (Fig. 3E) on the inside of the loading-rack.

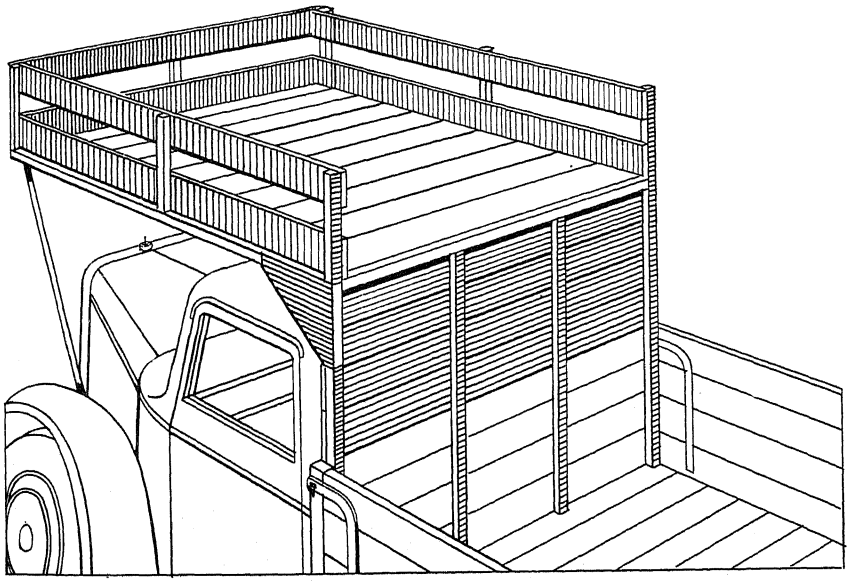


Fig. 4.—LOADING CAPACITY OF LORRY INCREASED BY MEANS OF A PLATFORM ABOVE THE CAB ROOF AND BONNET

Front Racks

Similar loading-racks may be secured in front of the body, or the front boarding may be extended so that the lorry has a high, close-boarded front, similar to the lorry shown in Fig. 4.

Building Platform above the Cab

Another method of increasing the loading capacity of a lorry is to build a platform above the cab roof (Fig. 4). This scheme may be adopted for a vehicle with normal or forward control, but with normal control there is the advantage, if a large area of platform is required, that it may extend over the bonnet.

Corner Pillars

To build this platform, corner pillars of $1\frac{1}{2}$-in. by 2-in. ash or oak are fitted in the front corners of the lorry, extending from the floor to the top of the platform enclosure. The 2-in. dimension of the corner pillar is placed parallel with the width of the lorry and on the inside of the front boarding of the body, which is usually of $\frac{3}{4}$-in. deal. The lorry, as a rule, is already provided with outside front corner plates, which may be utilised to secure the foot of the pillar. The existing bolts are removed and replaced by longer ones.

Intermediate Pillars

Two intermediate pillars are now required, the length of which is determined by the height of the platform floor. These pillars, also the higher corner pillars, are half-lapped to the rear cross-rail of the platform, which supports on top of it four lengthwise bearers. The floorboards are laid crosswise directly on these bearers. The front boarding of the lorry is continued upwards to the rear cross-rail.

Platform Cross-bearers

Cross-bearers 2 in. by $1\frac{1}{2}$ in. are bolted under the lengthwise ones. There is a cross-bearer at the front of the platform, and another midway between it and the rear cross-rail. Stump pillars 8 in. high, or according to the height of platform enclosure required, are lapped to the outer lengthwise bearers. Battens $\frac{5}{8}$ in. thick are screwed on the inside of the stump pillars and form the enclosure. In order to strengthen the joint between the front of the lorry and the back of the platform, a gusset plate of $\frac{1}{8}$-in. sheet steel is screwed on the outside of the outer lengthwise bearer and corner pillar.

Front Stays

The front of the platform is supported on a pair of stays of $\frac{3}{4}$-in. round iron which converge towards the bottom and have flaps so that they may be bolted to the chassis.

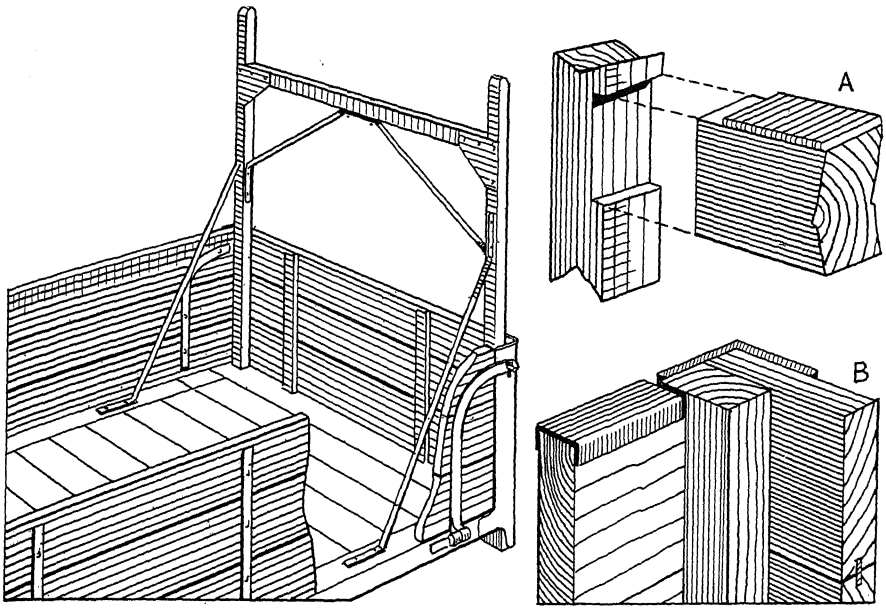


Fig. 5—DROP-SIDED LORRY FITTED WITH A FRONT GANTRY FOR CARRYING TIMBER
A. Joint of cross-bar and pillar. B. Cross-section of front gantry pillar at top of lorry side.

FRONT GANTRY

The utility of a drop-sided lorry is increased if it is fitted with a front gantry (Fig. 5), so that it may carry timber and other lengthy articles. The corner and intermediate pillars with their cross-rail, already described for supporting the rear edge of the loading platform above the cab (Fig. 4), could be utilised as a gantry, especially if the lorry has a high boarded front.

Top Bevel of Cross-rail

With the front of the lorry the same height as the sides, the gantry consists of a pair of 2-in. by 2¼-in. wooden pillars, the feet of which are bolted to the front corners of the lorry. The cross-rail (Fig. 5A) is 2 in. by 2½ in., with its top surface bevelled. This bevel is obtained by drawing to scale a triangle the base of which represents the length of the lorry and its height the distance from the floor to the top of the gantry cross-bar. Completing the triangle the hypotenuse represents the slope of the load, also the correct bevel for the top of the cross-rail.

Cross-bar and Backstays

The joint of the cross-rail with the pillar is reinforced with a gusset plate of ⅛-in. sheet steel, and the top edge of the cross-bar with a length of

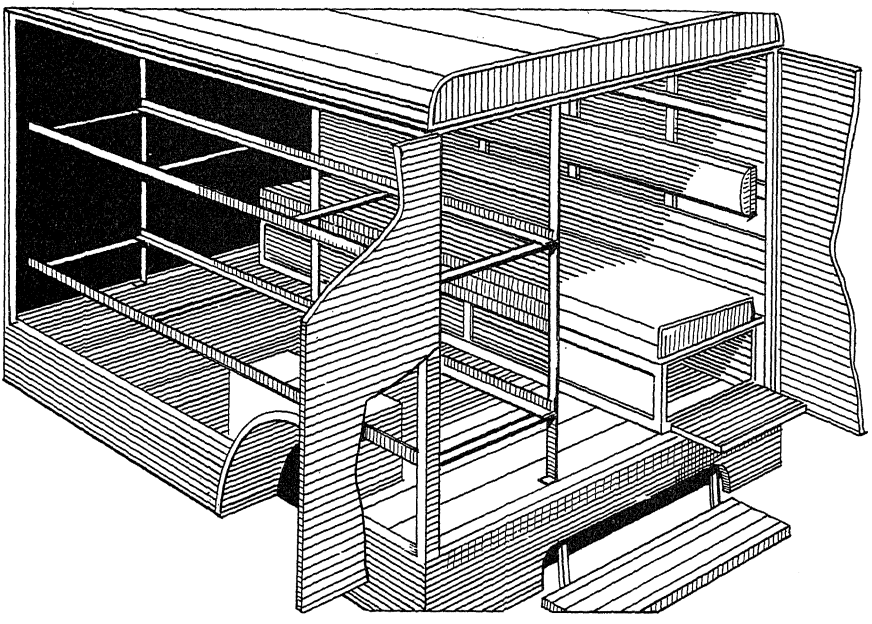


Fig. 6.—VAN CONVERTED INTO AN AMBULANCE WITH ALL-METAL STRETCHER BASE ON THE NEARSIDE FOR TWO STRETCHERS AND A LONG SEAT ON THE OFFSIDE

2-in. by $\frac{1}{4}$-in. flat mild steel. The gantry is strengthened by a pair of diagonal stays of $\frac{3}{4}$-in. round iron which are flapped under the cross-bar and to the inner face of the pillar. There is also a pair of backstays which prevent undue strain on the front of the lorry and distribute the thrust of the load.

Lower Fixing of Backstay

These backstays are also of $\frac{3}{4}$-in. round iron, and are flapped on the back of the pillar and on top of the bottom side. The last named is the outer lengthwise member of the bottom framework of the body. Its top surface may be exposed if the edges of the floorboards are rebated into it. Otherwise the floorboards are laid on top of it. In any case, the bolts which hold the lower end of the backstay must pass through the bottom side and not through the floor only, so as to ensure a secure fixing.

CONVERTING BOX VANS TO AMBULANCES

The adaptation of existing bodywork so that the vehicle may be used as an ambulance for A.R.P. work, either for official use or as part of the civil-defence equipment of a factory, is a means of providing this special form of transport for a moderate outlay. A box van is the most suitable type of vehicle for this kind of conversion. The lower the floor the better

and, in any case, a van which has a floor entirely above the hind wheels, that is, without inside wheel-arch enclosures, should not be used.

Wide Rear Opening

At the back there should be a pair of doors so as to afford a wide opening convenient for loading. Also, it is an advantage if these doors open the full width of the van, so that a loaded stretcher may be slid into the ambulance close to the side of it. When the van has only a single door at the back this should be at least 30 in. wide, but if the vehicle is suitable in other respects it is worth while altering it by increasing the width of the back opening and hanging a new pair of doors.

Length Required for Stretcher

The most important consideration when selecting a van for conversion into an ambulance is its length. A service stretcher is 7 ft. 9 in. long over the handles, so that at least 8 ft. inside accommodation is necessary. Any extra length available will be valuable to provide a cross-gangway, or for adding a crosswise seat for sitting patients.

Width of Stretcher and Seat

Regarding the inside width of the bodywork, this should not be less than 5 ft. 2 in. A good average width is 5 ft. 6 in., so that a central gangway at least 14 in. wide is available. Each stretcher is 1 ft. $10\frac{1}{2}$ in. wide, and the stretcher base, if of metal, will be about 2 ft. overall, and a wooden stretcher base two or three inches wider. More width is required for a vehicle with stretchers on both sides than for one which has stretchers on one side and a seat on the other. This is because the width of the seat need not exceed 1 ft. 6 in., or 6 in. less than the minimum width of a stretcher base.

Ambulance Headroom

A van which has a minimum length of 8 ft. will usually have sufficient headroom for the stretcher-bearers to enter the ambulance. The inside height from the floor to under the crown of the hoopsticks, or roof framework, should not be less than 5 ft. 10 in. for the stretcher-bearers to stand upright, but even with specially built ambulances this dimension is often reduced to 5 ft. 6 in., which is sufficient if the bearers do not enter the vehicle when loading the stretchers into it. This dimension is also sufficient for a stretcher base which accommodates upper and lower stretchers.

No Extra Load Entailed

As the van of the required length has been designed to carry at least 15 cwt., its new use will not entail the carrying of any extra load, because allowing $1\frac{1}{4}$ cwt. for each adult, 15 cwt. represents the total weight of twelve adults, or eleven adults and 1 cwt. of stretcher base and other equipment.

Two Types of Equipment

As already indicated, there are two leading types of equipment for the converted ambulance. One consists of a base on the nearside for two stretchers and a lengthwise seat on the offside for sitting patients and one or two attendants, as shown in Fig. 6. The other type of ambulance has a double stretcher base on each side with a seat for the attendant facing the rear at the front end of the central gangway.

Construction of Stretcher Base

A stretcher base is made of $1\frac{1}{2}$-in. by $1\frac{1}{2}$-in. angle- and flat-section mild steel. For a base of 8 ft. long, three stanchions of flat-section steel are required for each side, so that the assembly is supported entirely from the floor. The lower pair of stretcher runners should be as close as possible to the floor, and their height is determined by that of the wheelarch enclosure. The upper pair of runners is placed 2 ft. above the lower ones. Assuming that the wheelarch enclosure is 12 in. high, and 6 in. is allowed above the top pair of runners, the stanchions will be 3 ft. 9 in. high. The stanchions may also be extended so that they may be fixed to the roof framework, which is advisable if one pair of runners is attached to the body side instead of to independent stanchions.

Securing Cross-bars and Stanchions

The stanchions are connected by flat-section cross-bars, which are cut 2 ft. 3 in. long, so that $1\frac{1}{2}$ in. each end may be turned at right angles for bolting to the inside of the stanchions. The angle-iron runners are then laid on the cross-bars and bolted or spot-welded. The assembly is completed by bolting it to the floor with an angle-bracket secured on the inside of the foot of each stanchion.

Floor Repairs

Before fixing the stanchions the floorboards should be examined and faulty ones replaced, or loose ones made secure. A thin floorboard may be reinforced with a batten on the underside at the bolt position of the stanchions.

Long-seat Construction

The lengthwise seat, without the cushion, is 1 ft. 4 in. high, 1 ft. 6 in. wide, and as long as the inside length of the van. The seatboard consists of three 6-in. by $\frac{3}{4}$-in. boards, battened on the underside with four 3-in. by $\frac{3}{4}$-in. battens. The seatboard may be supported at the back on an existing rave, or lengthwise rail of the body framework. Otherwise an extra rail is screwed to the pillars at the required height.

Heelboard of Seat

The heelboard, or the board which supports the seat in front, is made of a framework of 3-in. by $\frac{3}{4}$-in. battens panelled on the inside with ply-

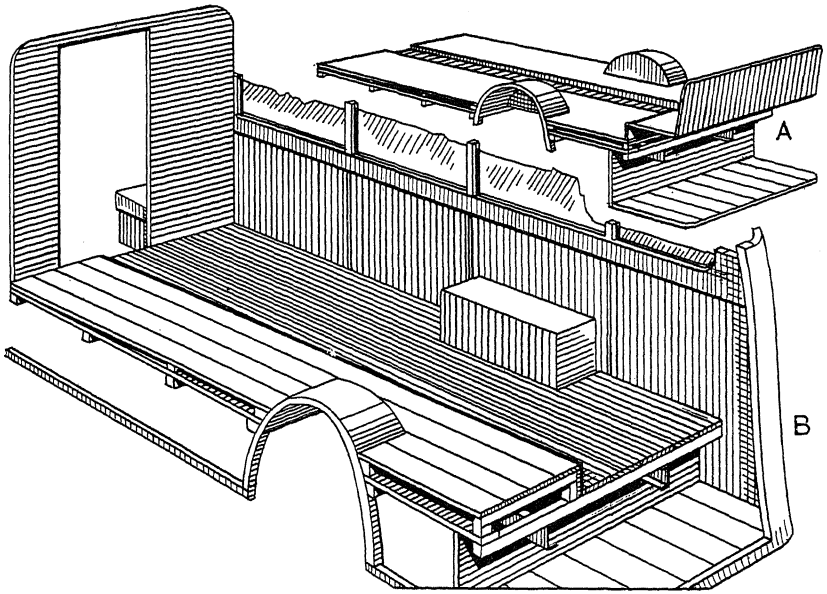


Fig. 7.—CONVERTING COACH INTO VAN

A. Ramped floor of coach with sunk central gangway, also showing position of back seat and floor of rear locker. B. Converting a coach into a van. The offside portion of the ramped floor has been made level with the central gangway, also the wheelarch made up into a rectangular enclosure. The back seat has been removed and a partition added behind the driving-seat.

wood. A similarly panelled framework may support the seat at the back, so that it is a box-like structure without a bottom, except for four cross-bars of 3-in. by ¾-in. material which are lapped to the bottom rail of the heelboard and backboard. If the seat is built into the body, then the heelboard is attached to the floor by small corner plates. With the box form of construction three screws in each bottom cross-bar will be sufficient to keep the seat in position.

Locker Space

The seat, except for the obstruction of the wheelarch, forms a comparatively large enclosure which may be used as a locker for first-aid supplies or an extra folded stretcher. Access is afforded by hinging portions of the heelboard, while the stretcher is easily accessible if an end door is fitted, as shown in Fig. 6.

Back Rest

The equipment for sitting patients is completed by adding a back rest. This consists of a 1-in. board 8 in. wide, which is screwed to the pillars at a height of 2 ft. above the seatboard, measuring to the top of the back rest.

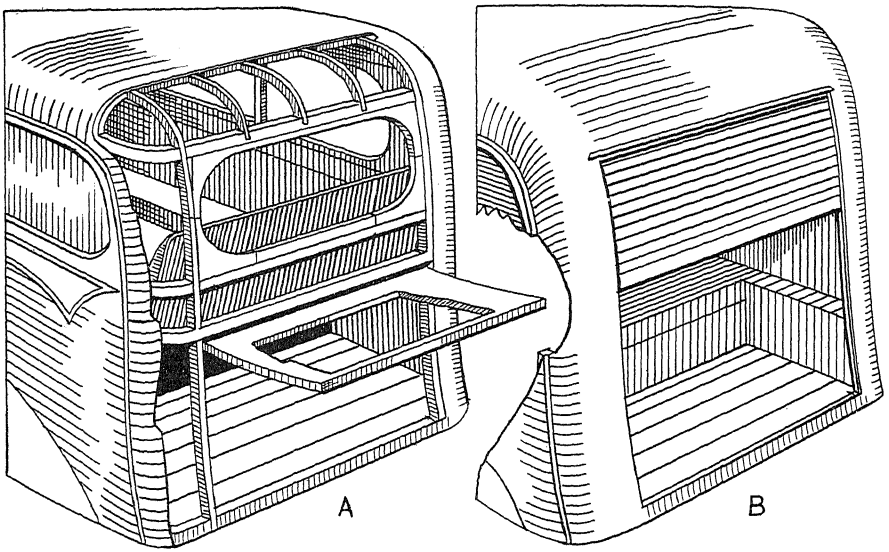


Fig. 8.—CONVERTING COACH INTO VAN

A. Back of coach with panels removed before cutting rear opening for conversion into a van. B. Rear opening completed and fitted with a roller shutter.

This is stuffed with horsehair or other suitable filling and covered with leather cloth.

Back Steps

If the ambulance is to carry sitting patients easy access to the floor level should be provided. A single step with a tread about 8 in. wide should be fitted for a floor not more than 24 in. high, and a double step for a floor height from 24 in. to 34 in.

CONVERTING A COACH INTO A DELIVERY VAN

A new coach may have been completed and it cannot be placed in service owing to fuel rationing, or it has been built for stock or exhibition and is difficult to sell owing to restrictions of services. In other instances, a coach body has been partly constructed and work on it has been abandoned owing to the conditions prevailing. Also, second-hand coaches may be awaiting new owners. Whether new or second-hand, there is the opportunity of using these vehicles by converting them into delivery vans. The coach will make a large-capacity van, and will probably weigh more than 50 cwt. unladen, so that it will be subject to a speed limit of 20 m.p.h.

Removal of Interior Equipment

The equipment to be removed from a completed coach includes the passenger seats, also the back seat, which is built into the body, and the inside parcel racks and any lamps which project from the sides of the body. The windows are removed and plywood panels of the same thickness are substituted for the glass.

Alterations to the Coach

The coach usually has a ramped floor on each side under the seats which slopes upwards to the rear (Fig. 7A), with a sunk gangway between them. The sunk gangway must be made level with the floor under the seats, and if the ramp is sufficiently sloped to cause the load to shift towards the front, then the floor is relaid and the cross-bearers which support it are altered so as to provide a horizontal bearing. The usual front sliding door and the hinged offside emergency exit opposite to it are not suitable for goods loading, except for small packages. Therefore, the back of the coach is cut away so that a pair of doors or a roller shutter may be hung here (Fig. 8B). The rear luggage locker, which is usually built under the hind seat, is incorporated into the main portion of the body, and provides an easy means of access to it (Fig. 8B).

Relaying the Floor

If the floor has to be relaid, then the raised portions which were under the seats are removed, also the framework which supports them. By this means the main cross-bearers at the sunk gangway level are exposed. The floor at the sides of the body is then relaid so that the floor is at the same level throughout.

Rectangular Wheelarch Enclosure

In order to separate the loading portion of the body from the driving compartment, a partition is built between them which may have an opening in it fitted with a sliding door. The position to select for the partition is the nearest body pillar behind the driving seat. The uprights of the framework which support the boarding of the partition are screwed to the body pillars. All pillars of the partition, including the intermediate ones, are screwed at the top to the roof framework and at the foot to the cross-bearer. This part of the work is done before relaying the floor.

Removing the Back Panelling

The back of the coach has now to be provided with an opening suitable for a delivery van. The mouldings are removed so that the panels may be detached and the framework exposed, as shown in Fig. 8A. The door of the luggage locker is removed, also the back-light framework. The cross-rails at the waist are cut through, but not the rail immediately above the back-light, which is to be the top rail of the new opening. A

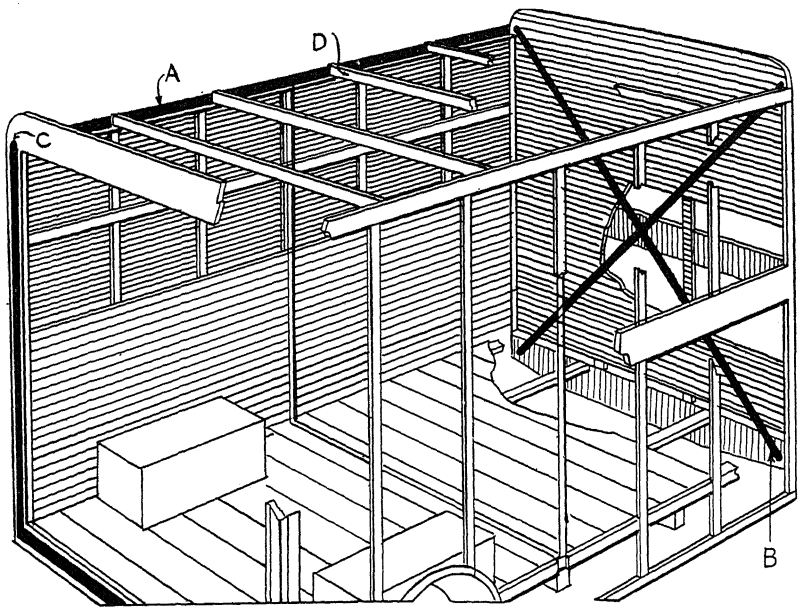


Fig. 9.—REINFORCED FRAMEWORK OF DELIVERY VAN

Angle-irons A, front braces B, and hind body plate C, placed so that the van may be used for carrying meat with the carcases hung by hooks from the cross-rails D.

sufficient area of the domed top back panel is replaced and replenished where necessary.

Roller Shutter Preferred

The rear opening so formed may be fitted with a pair of doors, a tail-board with a pair of smaller doors above it, or a roller shutter. As the back of the body is curved, the roller shutter will be the most economical plan, because it will adapt itself readily to the curved shape. The making of a pair of curved doors entails considerable expense and, owing to the inclination of the hinge centres, the doors will require stays to keep them open when loading the vehicle.

CONVERSION OF VAN TO CARRY MEAT

The majority of box-van bodies are designed for carrying a load piled on the floor, or some of the articles are carried on shelves. But it is only in special cases that the greater part of the load is suspended from the inside of the roof. The framework of the roof of many vans is only strong enough to hold the top of the sides of the body rigidly together and to support, when necessary, an extra load carried on the roof of about 1 cwt. The distribution of meat to centres where the population has been

temporarily increased necessitates the use of more meat vans such as are used for market work. With this type of van the carcases are suspended from the roof, also it is designed so that it may be easily kept in a clean condition.

Strengthening the Sides at the Top

An ordinary box van of from 2 to 4 tons carrying capacity may be converted for carrying an inside roof load by reinforcing the framework. The first requirement is a length of 2-in. angle-iron (Fig. 9A), which runs the full length of the van and is bolted to the pillars or standards immediately below the cant rail, or top side member of the body framework. If the cant rail is of sufficient depth, then the angle-iron may be bolted to it immediately below the roof ribs or hoopsticks, or a new hardwood rail is added to provide the required depth of bearing for the angle-iron.

Front Braces

The front of the body is also strengthened to resist the thrust of the load. This is done by adding a pair of cross-braces (Fig. 9B) of 1-in. by $\frac{3}{4}$-in. flat steel which extend from the top cross-rail to the front bearer under the floor. These braces may be added without removing the front boarding, although it will be necessary to cut a slot in the floor in each front corner in order that the braces may pass through to the bearer below.

Hind Body Plate

The back of the van is probably already stiffened with a hind body plate (Fig. 9C) which extends across the hind bearer below the doors or tailboard. This body plate has flaps extending up each hind-corner pillar.

Bolt Ends for Side Angle-irons

It is an advantage if the angle-irons each side of the roof can be connected to the braces in front and to the flaps of the body plate at the rear. For this purpose a bolt end is welded at each end to the angle-irons. This bolt end then passes through an eye in the end of the front brace and the flap of the body plate, and is secured with a nut on the outside. The flaps of the backplate will require extension, so that they are removed and the required length of flap welded on.

Hygienic Considerations

A meat van should be lined with sheet zinc. This lining includes the sides and front of the van below the waist, also the back doors and floor. As sheet metal may be difficult to obtain, these parts should be reboarded or panelled where necessary so that there are no crevices where dirt may accumulate and be difficult to dislodge. The inside of the body is then repainted.

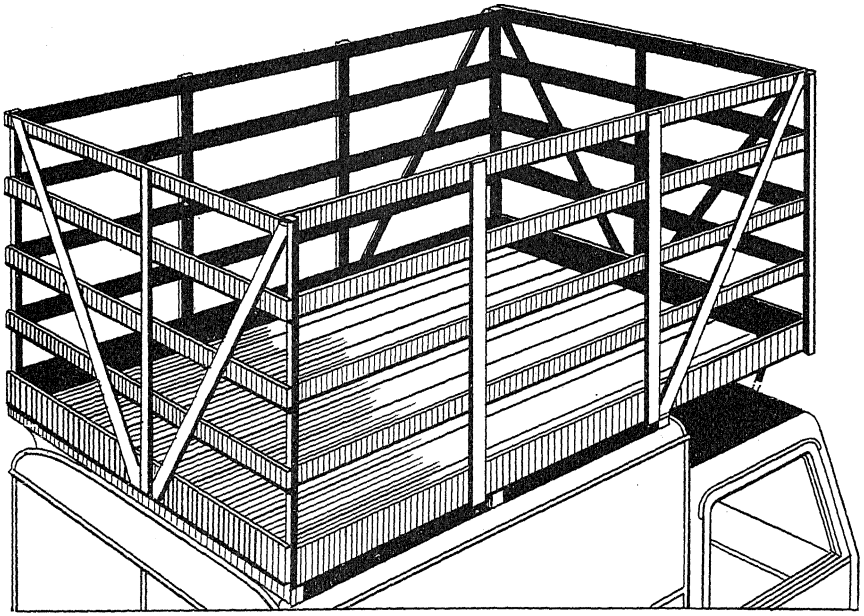


Fig. 10.—LIGHTLY BUILT CRATE WHICH CARRIES A BAG FOR A VEHICLE RUNNING ON TOWN'S GAS

Floor Mats

The floor of a meat van is covered with wooden mats. These consist of 2-in. by $\frac{3}{4}$-in. deal battens, spaced about 1 in. apart and battened on the underside with similar material. A crosswise batten screwed on the floor at the back will keep all the mats in position. The floor is covered with a set of four mats, and if there are wheelarch enclosures, then one pair of mats is designed to fit around them. A mat which covers the floor both in front and behind the wheelarch will keep the mat in front of it from moving. These mats are scrubbed periodically, and, incidentally, they save wear on the floor.

Cross-rails for Meat Hooks

The angle-irons at the top of the body sides not only strengthen the van, but also provide a foundation for a set of cross-rails (Fig. 9D) fitted with hooks, from which the carcases are suspended. The cross-rail is of 2-in. by 1-in. hardwood, and it is flitch-plated on one side with a steel plate $\frac{1}{4}$ in. thick. The ends of these rails have iron pins which drop into holes bored in the side angle-irons, or the cross-rails drop between small brackets made of short lengths of angle which are spot-welded to the side angle-irons. The latter method is to be preferred, because neither the cross-rails nor their supporting angles are weakened by fitting pins or by drilling holes.

MAKING A GAS-BAG CONTAINER

Rationed fuel has brought again into prominence the use of alternative fuels, and for this reason vans and lorries have already been fitted with an equipment so that they may be operated on town's gas. It is estimated that 250 cu. ft. of gas is equivalent to 1 gall. of patrol. Gas bags are made in various sizes, such as to hold 240, 360, 480, and 600 cu. ft. respectively. Each bag is 6 ft. wide and 4 ft. high, and varies in length from 10 to 25 ft. In order to decrease the overall height of the vehicle, such as a box van, part of the gas supply may be carried in a net under the roof inside the body and the remainder in a crate on the roof. Any special size of gas bag can be made to order.

Width and Length of Crate

A lightly built crate for carrying a gas bag is shown in Fig. 10. In order to provide maximum capacity the crate should be as wide as the overall width of the vehicle, and, as the sides of the roof are curved, cross-bearers are placed across the roof to support the side overhang of the crate. The cross-bearers are placed immediately above alternate roof ribs or hoopsticks, so that the cross-bearers may be screwed to them. The crate is also the full length of the vehicle, and the bottom of it may be shaped to conform to a cab roof which curves downwards in front. If the cab roof is at a different level from that of the loading portion, as in Fig. 10, then the projecting portion of the crate is supported on a pair of iron stays.

Height of Crate

The crate may be high enough to enclose entirely the inflated gas bag, or about half of it is allowed to project at the top. In any case, a net is stretched over the top in order to control the movement of the bag whilst the vehicle is travelling.

Construction of Crate

The crate is made of $1\frac{1}{2}$-in. by $\frac{1}{2}$-in. deal battens with braced ends, as shown in Fig. 10, also side braces to add to the rigidity if there is a projecting front portion. One method of constructing the crate is to fix the side frames inside the end frames, and to secure them with corner plates. The floor of the crate may be of spaced strips of plywood, and the sides are left open, or panelled on the inside with plywood.

ANDRE HYDRO-TELECONTROL SHOCK-ABSORBER SYSTEM

By GEORGE T. CLARKE

IN the Andre telecontrol system, although the control itself is hydraulic, the absorber is not. The system is a non-compressible-fluid method of controlling the pressure exerted at the will of the driver on the friction discs of the absorber.

Frictional and Hydraulic Absorbers

Shock absorbers can, broadly speaking, be divided into two characteristically different classes, frictional and hydraulic. With the former the spring-damping resistance is effected by frictional means, in the latter a fluid provides the necessary resistance. Both have the same objective, that is, to control undesirable spring vibration, but differ considerably in action. Hydraulic absorbers depend in their action upon the transfer of fluid, usually under high pressure, from one chamber to another through a small orifice. The system is subject to temperature conditions. Friction absorbers are somewhat simple in action and unaffected by temperature conditions. The damping action with the hydraulic absorber is controlled at the absorber by regulation of the orifice. The friction absorber is controlled by a spring acting on the friction discs.

Components of Telecontrol System

The Andre telecontrol system consists of friction-disc absorbers, dashboard regulators, pressure gauges, fluid reservoirs, and the necessary pipe connections. The copper pipes are $\frac{3}{16}$ in. outside diameter, and easily bent to shape and fitted to the average car if not fitted with the system in the first instance.

Adjustable Shock Absorbers

Shock absorbers of the ordinary fixed-adjustment type, however efficient in actually controlling undesirable spring action, can only be set one at a time, whatever the merits within the absorber itself. To enable the suspension system to give a maximum degree of riding comfort at all conditions and speeds over smooth and rough roads, it is advisable to have a variable damping value and controllable whilst driving. A car carrying only the driver needs a different adjustment of the absorber to the same car carrying a full complement of passengers.

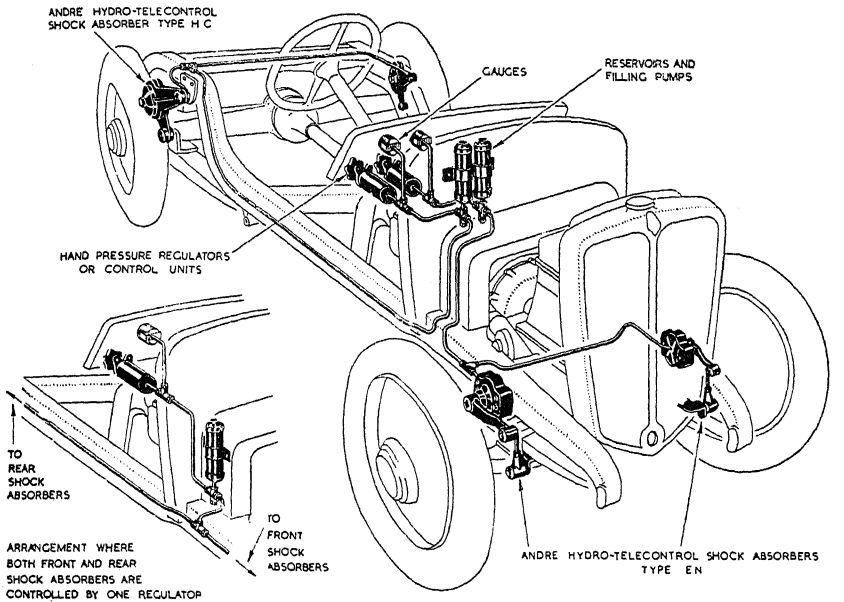


Fig. 1.—GENERAL ARRANGEMENT OF ANDRE TELECONTROL SHOCK-ABSORBER SYSTEM

Assume luggage equal in weight to two rear-seat passengers, but, instead of the passengers the luggage is placed on the platform, thus overhanging the rear axle. The result would not only be felt by the rear absorbers, but the front absorbers would be relieved of certain work by the fact that the front axle has then a tendency to be lifted from the ground. The front and rear absorbers are thus, if good springing is desired, working under different conditions, and therefore should have different adjustment. Passengers plus luggage require another change of both sets of absorbers, and this is what the telecontrol system attempts to attain.

Telecontrol can give either a small damping effect for town use, or slow travel, or, when desired, a greater damping resistance for fast driving, perhaps over indifferent roads.

Advantages of the System

The degree of adjustment with the Andre telecontrol system is instantly regulated from the dash to suit any combination of road, load, or speed conditions. A dash indicator shows the hydraulic pressure controlling the system. The telecontrol system can be disconnected should anything go wrong, and the friction absorber operated as a self-contained unit.

Telecontrol Absorber Unit

The absorber unit comprises a frictional-type absorber and the hydraulic-pressure unit. The two assemblies are self-contained, but are interconnected by means of a central bolt to form the complete absorber, or alternatively, in cases of necessity, the absorber can be operated as on the ordinary frictional system by the adjustment of a regulating nut as used on the original Hartford absorber. The hydraulic unit consists of a rubber expander with internal channels for the fluid. The expander is enclosed in a metal container and held in position by a central bolt connecting with the end plates on each side of the frictional absorber. The metal case forms the protection from climatic conditions.

The Regulator

The regulator consists of a cylindrical casing in which moves the flexible container holding the operating fluid. This container is compressed by means of a screwed plunger attached to the hand-controlled wheel, a pressure equal to that applied in the container being transferred via the connecting pipes to the absorbers. The regulator is almost frictionless and leakproof.

Pressure Gauge

The degree of adjustment is registered on the dash by means of one pressure gauge if all four of the absorbers are under one control, but two gauges if the rear absorbers have a separate control from the front absorbers.

Reservoir and Filling Pump

The purpose of a combined reservoir and filling pump is to facilitate the initial process of charging the system, and to provide a reserve of fluid for the replacement of any loss caused through accidental damage. The whole unit consists of the reservoir containing a hand-operated plunger pump fitted with a non-return valve. The screwed head of the plunger forms the filling cap, which, upon being screwed down, seals the non-return valve orifice.

Pipe Connections

The $\frac{3}{16}$ in. copper pipe forming the line from the controls to the absorbers has no soldered joints, the method being that of double conical nipples such as used with the Autovac system and general American pipe practice.

System of Operation

The damping resistance of the absorber is applied from the control unit by the movement of a column of liquid via the pipe line to the expanders. The liquid, being incompressible, constitutes an hydraulic

force, a pressure equal to that imposed in the regulator being exerted in the expanders. The action is instantaneous. The expander in each absorber, being of equal area and being operated by equal pressure, exerts equal pressure on the friction discs.

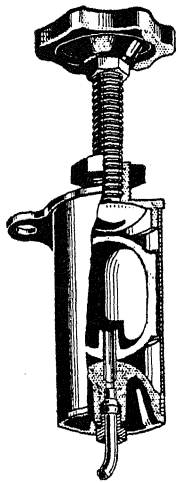


Fig. 2.—REGULATOR SHOWING HAND-WHEEL FULLY OUT

MAINTENANCE INSTRUCTIONS

Under ordinary circumstances the system is trouble-free, but there may be some unavoidable causes or accidental derangement that necessitates the aid of the mechanic to effect rectification or renewal.

Pressure Variation

Temporary variation in pressure indicated on the gauge of a few pounds up or down is not of consequence, as this may be due to variation in temperature of the liquid owing to climatic conditions, etc. Also, in this connection, it may be noticed that the vehicle, after a long run, tends to increase the pressure somewhat. It is due to frictional heat generated, and is unimportant. Should there be constant loss of pressure, investigation should be made.

Refilling Regulator

The absorbers may become inefficient through loss of liquid, due to accidental damage, or leakage when connecting up. If the leak is not serious and is indicated only by a gradual drop in pressure over a period, or if the desired pressure cannot be obtained even when the regulator is screwed right down, the system can be temporarily "topped up" by means of the reservoir pump until such time as it may be convenient to trace the cause of the trouble. If the loss of pressure is rapid, then the leak, if any, must be traced and cured immediately. After such a leak it will be necessary to refill the regulator, Fig. 2.

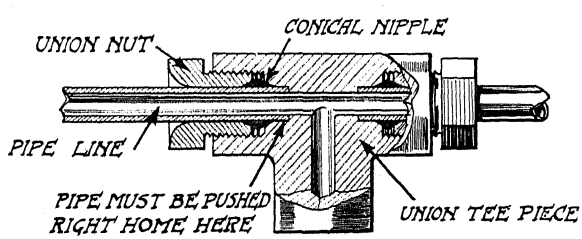


Fig. 3.—JUNCTION UNION

Showing the double conical nipples and the need for carefully pushing the pipe lines right home before doing up the union nuts.

With the hand-wheel right "in" to the end of its travel, begin to pump fluid from the reservoir filling pump until the

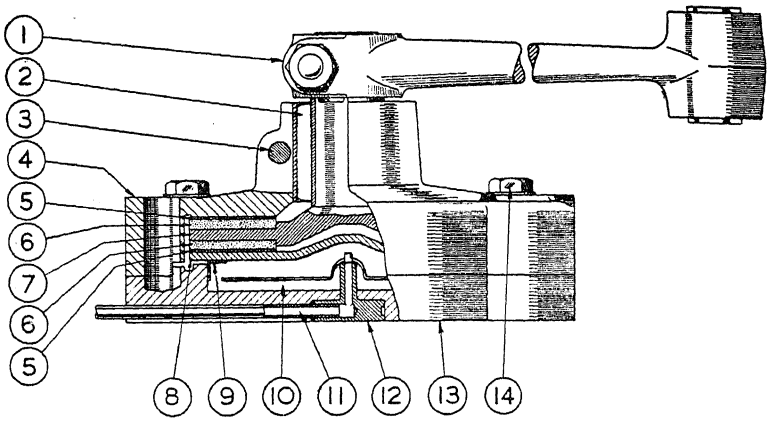


Fig. 4.—MODEL E.N. SHOCK ABSORBER

1, Absorber Arms. 2, Silentbloc Bush on Spindle. 3, Bush Coupling Bolt. 4, Top Half Case. 5, Interleaving Discs. 6. Friction Discs. 7, Rotor. 8, Pressure Plate. 9, Retaining Ring. 10, Hydraulic Expander. 11, Control Pipe end. 12, Control Pipe Connector. 13, Lower Half Case. 14, Four Bolts securing Half Cases.

gauge reads about 50 lb. per square inch, then unscrew the hand-wheel until the pressure drops to 10 lb. per square inch. Pump in enough fluid to raise the gauge pressure again to 50 lb., and reduce once more to 10 lb. by unscrewing the hand-wheel. Repeat this sequence of operations until the hand-wheel is unscrewed to the limit of its travel with a gauge reading of 20 lb. Finally, screw the pump plunger firmly down to seal the system. This method ensures that no air is drawn into the system. If, for any reason that cannot be ascertained or remedied, the hand-wheel when screwed to the limit of its inward travel does not develop a near maximum on the gauge, and this pressure is desired, a little more fluid may be pumped into the system until the gauge shows approximately 30 lb. pressure. The higher pressure should then be easily obtained. During these operations the reservoir must at least be half-full, otherwise air may be pumped into the system.

Union Leakage

This is indicated by gradual loss of pressure, necessitating very frequent adjustment of the control unit. Unless they have been disconnected several times, the nipples seldom give trouble ; after this the conical nipples may have become dislocated and new cones should be fitted (*see* Fig. 3). A nipple in use becomes embedded in the pipe and cannot be removed, therefore the pipe end close to the nipple must be cut off squarely. This shortens the pipe, but a short length can generally be gained by straightening out somewhat the nearest bend or curved part

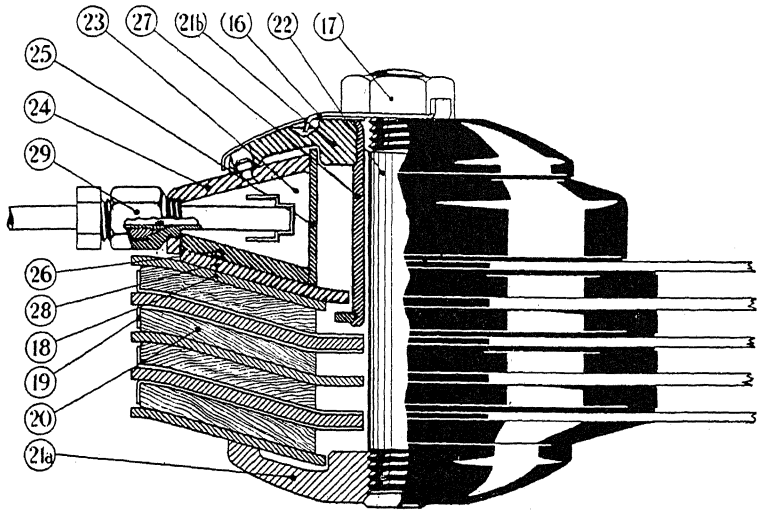


Fig. 5.—MODEL H.C. SHOCK ABSORBER

16, Locking Washer. 17, Lock Nut. 18, Absorber Arms. 19, Friction Plates. 20, Friction Elements between Absorber Arms. 21A, Clamping Plates, 21B, Clamping Plates. 22, Central Bolt. 23, Rubber Expander. 24, Metal Cover. 25, Sleeve. 26, Disc. 27, Flanged Sleeve. 28, Disc. 29, Control Pipe Union Nut.

of the pipe line. When fitting nipples, be sure to clean the burrs off the end of the pipe, but do not file the surface on which the cone has to fit. See that the pipe is well home in the housing before tightening; also do not tighten too forcibly.

After a leak has been rectified, more fluid may be needed. In this case always connect the pump up loosely at first, then force a little fluid past the loose connection before tightening up. This means that any air trapped in the pump connection will be expelled before entering the pipes. Any joint that has been unscrewed, or a joint re-made, should be "bled" whilst it is being tightened.

Defective Expander—Model E.N.

In this case there is a fair drop in pressure, and the liquid can be seen issuing from the absorber when the control unit is being operated. Should it not be possible to return the unit to the makers, who are best fitted to make the repair, it will be necessary to replace the defective unit.

Referring to Fig. 4, after disconnecting the absorber from the chassis by removing the two fixing bolts, take out the four bolts (14) and separate the two halves of the absorber casing (4 and 13). Disconnect pipe connection (12) by means of a small lever or screwdriver in the groove provided. Retaining ring (9) and the expander (10) are lifted out to-

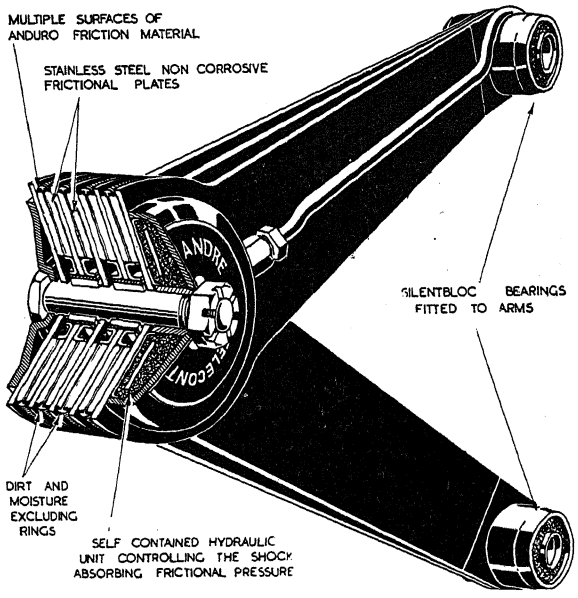


Fig. 6.—SECTIONAL VIEW OF TYPE H.C. ABSORBER

gether, and the new expander is fitted into the base. The absorber should next be reassembled and the pipe connector (12) reinserted. It is advisable to moisten the portion of the pipe connector (12) which enters the rubber expander (10) with water before inserting. Replace and refill as instructed.

Defective Expander —Model H.C.

The special construction of this type of telecontrol absorber enables the hydraulic unit containing the expander to be readily disconnected without dismantling any part of the absorber frictional elements, or removing the absorber from the car (*see* Fig. 5).

Pull out the connecting pipe by unscrewing the union nut (29), then bend down the upturned edges of the lock washer (16). Unscrew locknut (17), and the complete operating unit can then be lifted off the centre bolt and the replacement effected. In this connection it is pointed out that the Model H.C. absorber can be operated entirely independently of the hydraulic control should there be a failure of the latter. The absorber operates as a normal friction damper by simply tightening up the external locknut (17). This operation compresses the rubber expander, and closing the inner cavities it excludes all liquid. The expander will then merely form a rubber pad, and any desired pressure can be exerted on the frictional elements by suitable adjustment of the locknut (17).

Frictional Section of the Model H.C. Absorber

The absorber comprises the arms (18), and these are faced with non-corrosive plates (19). The damping resistance is provided by frictional elements (20) which are interposed between the faces of the arms. The clamping plates (21*a* and 21*b*), one on each side of the absorber, are held in position by the central bolt (22). The nut (17) regulates the initial

pressure on the expander in the hydraulic operating unit; this adjustment is determined on assembly, and the adjusting nut (17) locked in position by the tag washer (16).

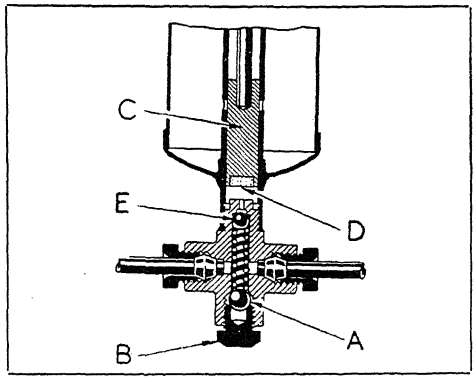


Fig. 7.—SECTIONAL VIEW OF LOWER PORTION OF RESERVOIR AND PUMP

A, Lower Ball. *B*, Screwed Plug. *C*, Plunger. *D*, Rubber Washer. *E*, Top Ball.

Operating Unit of Model H.C. Absorber

The self-contained assembly comprises the rubber expander (23), in which there are ducts to hold the operating liquid. The expander is encased by the metal cover (24), the sleeve (25), and the disc (26). Into the clamping plate (21*b*) is fixed the sleeve (27) with a flanged lower end forming a stop for the disc (28), which controls the movement of the expander. A union nut (29) is screwed into the metal cover for connecting to the dash control.

Frictional Section of Model E.N. Absorber

The assembly (Fig. 4) consists of an aluminium-alloy case in halves (4 and 13), the rotor (7), and the expander (10). The pressure is exerted by the expander (10), and the damping resistance obtained by the friction discs (6), which are interposed between the non-corrosive faces of the interleaving discs (5) and the faces of the rotor (7). The pressure is evenly distributed over the friction area by the pressure-plate (8). The rotor is pivoted in a silentbloc bush (2) to eliminate noise and wear. No lubrication to the bush is necessary.

Special Points when fitting the Model E.N. Absorber

Care should be taken that the clamping bolt (3) is left slack until the link and arms have been connected to the axle of the car. This enables the silentbloc bush to take its correct, and neutral, position in the housing. When everything is lined up and connected, the bolts (1 and 3) must be fully tightened.

Pipe Line and Regulator

A broken pipe or defective regulator means an immediate loss of pressure. The leak will be seen at the respective failures.

Defective Pressure Gauge

When the telecontrol is separate for front and rear axles, the gauges can be compared by interchanging, but if only one control is fitted for all

four absorbers the gauge should be sent to the makers for calibration, and the gauge pipe temporarily plugged.

Loss of Pressure in Reservoir and Filling Pump

Leaking ball valve.—Should the valve not be seating properly it will not be possible, except momentarily, to obtain any pressure on the gauge. The loss of pressure may be caused by foreign matter underneath the ball valve at the bottom of the reservoir, which allows the liquid to flow back into the reservoir instead of going into the pipe line. The latest model, shown in Fig. 7, incorporates the three-way union to make the necessary connections. In order to remove the ball valve, it is necessary only to remove plug (*B*), when the spring balls (*E*) and (*A*) will drop out. Examine, clean, and replace the ball (*E*), then the spring and ball (*A*). Do not forget to see that the plug (*B*) is tight but not overstrained. The rubber washer (*D*), which is inserted in the base of the plunger (*C*), forms a seal when the plunger is screwed right down.

The Hydraulic Fluid

The fluid as supplied by the makers consists of a 30-per-cent. solution of pure glycerine and distilled water, and should be easily obtained from a reliable chemist. The fluid used for other types of absorbers or brakes must not on any account be used. It has been manufactured for an entirely different purpose and therefore will ruin the system. If the correct solution cannot be obtained, the system can be filled with water (somewhat dangerous in deeper winter, owing to freezing), but as a very temporary expedient only.

Fitting Instructions

In view of the fact that the system is not fitted to all cars as standard, fitting instructions are given in so far as it enables the operator to overcome difficulties that may not be foreseen when the task is undertaken. The advice is based upon experience, but is not intended to show the fitter his business.

The usual arrangement where two regulators are employed is shown in Fig. 1. This provides independent control for both front and rear absorbers; therefore pressure can be varied for each pair as desired.

Two or One Controls

One regulator, indicator gauge, and reservoir-filling pump can serve to control all four absorbers, as shown in the inset in Fig. 1. The method is particularly applicable to smaller cars, and in this case all four absorbers are operated at the same pressure. The regulators should be fitted within easy reach of the driver, and the steering column or the instrument board is found to be the most convenient position. The gauges should be fitted well within view of the driver, so that he can readily see the desired press-

ure. The reservoir-filling pump, or pumps, must be placed in a vertical position, and the bulkhead under the bonnet is suggested as a suitable place. The pipe line should present no difficulties.

Fitting the Absorbers to the Chassis Frame, etc.

Two methods of fitting the absorbers are provided: (1) by a direct fitting to the chassis frame (Model E.N.), and (2) by means of brackets and studs in a similar manner to the ordinary type Andre-Hartford absorbers (Model H.C.). In the latter connection, if brackets are already fitted, the telecontrol system usually replaces without difficulty. Blue prints are supplied by the manufacturers to simplify the process. Clips of the correct type are provided for the pipe line. When there is likely to be movement where the line leaves the body and is fastened to the chassis, it is wise to leave a helix in the line to take up any play in body movement. After the line is in place leave the pipe ends adjacent to the absorbers, regulators, and gauges, loosely connected. They should not be tightened up until after filling, but connect up all other unions securely, including those to the reservoirs. When tightening the union it is important that the pipes are pushed right home into the shoulder of the union. Unless this is done there is liability to leakage. When tightening the unions to the T-piece, Fig. 3, under the reservoir and filling pump, always hold the hexagon nut on the outlet pipe to prevent strain. The conical nipples, supplied for making the pipe connections, take the place of the steel balls fitted to the absorbers for sealing purposes only. Each absorber and regulator is filled when it leaves the factory.

THE MORRIS TEN CHASSIS

SERIES M

Removal of Rear-axle Differential Assembly

RAISE the rear end of the car by suitable lifting tackle and support the rear axle on suitable axle stands, with the wheels clear of the ground.

Uncouple the propeller shaft at the rear universal-joint flange by removing the four bolts fastening the two halves of the flange together.

Remove the two wheels and unscrew the three countersunk-headed screws which retain the brake drum in position on the axle flange, and withdraw the brake drums.

The axle flanges should now be parted from the hub flanges by inserting two of the countersunk brake-drum screws into the two tapped holes in the axle flange, and using them as extractors.

Withdraw the axle shafts until they are clear of the differential assembly in the centre of the axle.

Remove the drain plug under the banjo of the axle casing, and allow the oil to drain away into a suitable receptable.

Release the jackall pipe, when fitted, by removing the two nuts with spring washers which attach it to the nearside of the differential housing, and carefully spring the pipes so that they are clear of the differential-housing flange.

Unscrew the remainder of the nuts retaining the differential-housing flange to the banjo, thus permitting the removal of the differential assembly complete.

Adjustment

The differential assembly follows normal Morris practice, except that tapered-roller bearings are employed and that the adjustment for the crown-wheel position is effected by means of ringnuts in place of the castle nuts previously employed. Otherwise the method of adjustment remains the same in principle, and the same care must be taken not to overtighten the crown-wheel bearings.

Removal of the Front Axle

Raise the front end of the car on suitable lifting tackle so that the front wheels are clear of the ground, and place suitable supports under the frame just behind the rear-end shackle brackets.

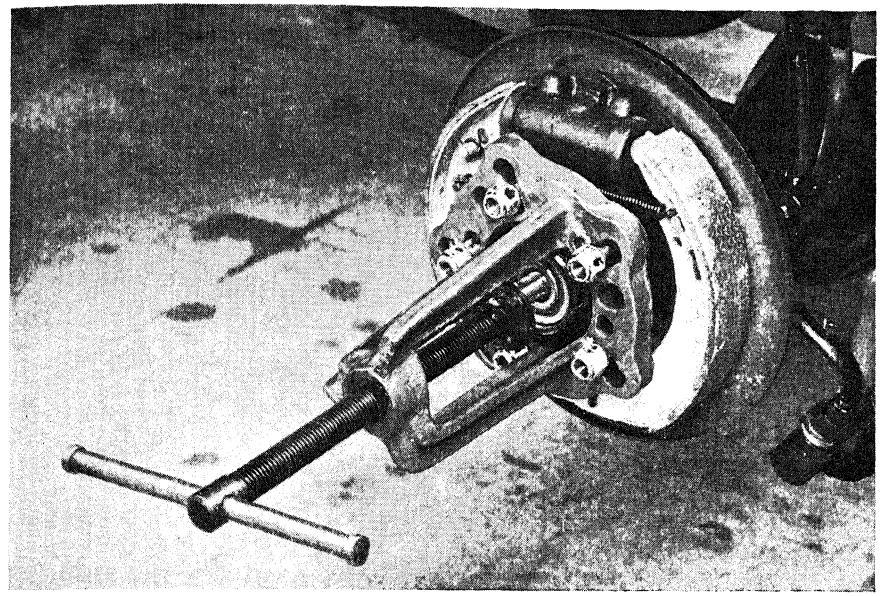


Fig. 1.—REMOVING THE HUB

The front hub is extracted from the axle, after removing the retaining nut, by the use of a standard hub extractor, as shown.

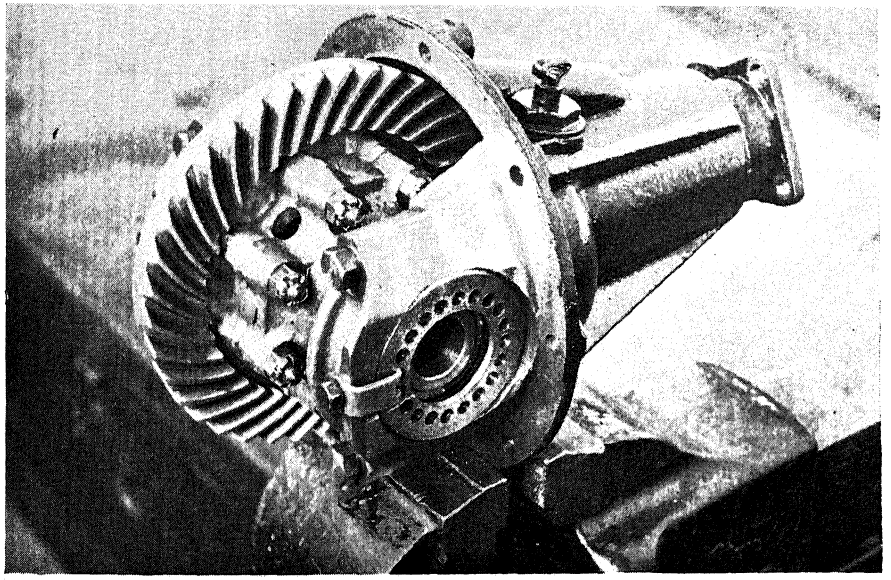


Fig. 2.—THE DIFFERENTIAL ASSEMBLY OF THE MORRIS TEN (SERIES M) WITHDRAWN FROM THE CAR FOR EXAMINATION AND ATTENTION

Remove the wheels and support the weight of the axle by placing a jack under its centre so as to take the load off the check straps.

Release the flexible pipes of the Lockheed brakes from the brake backplates, and, when jackall jacks are fitted, the flexible pipe leading to the front hydraulic jacks.

Remove the bolts attaching the check straps to the lug on the top spring plate, and release the shock-absorber connecting links by removing the bolts locating them to the front-axle brackets.

Unscrew the nuts and remove the shakeproof washers from the screws locating the torsion bars to the pressed-steel brackets on the front axle. Employing a suitable drift, carefully tap out the retaining screw half-way only.

By varying the extension of the jack under the axle a point will be found where the tension of the torsion bar is at a minimum. Keeping the axle in this position, the load on the screw should be further released by the use of a cranking iron on the axle beams. While an assistant applies downward pressure on the cranking irons to bring the torsion-bar bracket forward into the position where no load is placed on the retaining screw, the operator should manipulate the screw so that the degree of tension can be felt and the screw removed, as soon as it is free, without damage.

Release the lubricating pipes from the shackles at the rear end of the front springs by unscrewing their unions, and undo the setscrews which anchor the pipes to the shackle bolts.

The axle is now lowered by means of the jack until the load is removed from the rear shackle pins. Remove the nuts from the shackle pins and withdraw the side plates, remembering that the shackle pins are of the screwed type and cannot be knocked out. Remove, also, the felt washers beneath each shackle plate.

The forward anchorage of the springs is now released by slackening the anchorage pins of the rubber-backed bearings, noting that *fibre* washers are fitted to each side of the spring eye in this case.

With the help of an assistant the jack can be removed and the axle lowered on to the ground, permitting complete removal of the anchorage pins and final release of the axle assembly.

When reassembling it must be remembered that it is essential to centralise the pins of the screwed-type shackle pins, preferably using the special centring gauges obtainable from Messrs. Morris Motors. Care must also be taken to see that the shackle pins do not turn when the nuts are replaced on their ends and tightened up. Full details concerning the assembly of these screwed shackles is given in the section dealing with the Morris Eight (Series " E "), to which you are referred.

During reassembly, which is carried out in the inverse way to removal, use should again be made of the supporting jack and cranking bar to facilitate replacement of the components.

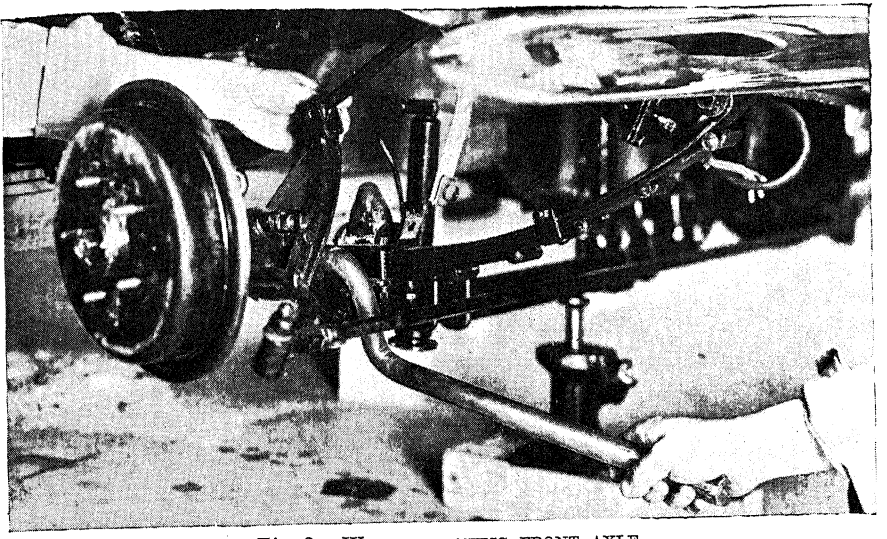


Fig. 3.—WHEN REMOVING FRONT AXLE

The use of a " setting iron " is necessary to relieve the torsion arms of the stabiliser from load while its attachment pins to the axle brackets are removed.

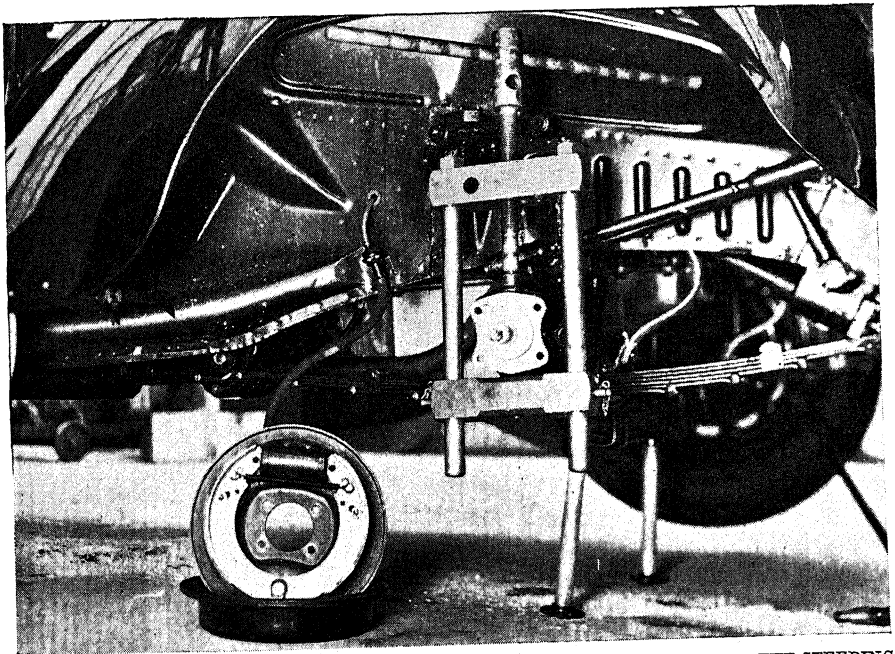


Fig. 4.—THE SPECIAL MORRIS EXTRACTOR IN POSITION FOR THE REMOVAL OF THE STEERING KNUCKLE PIN

Renewing the Steering Knuckle Pins and their Bushes

Attention may be given to the steering knuckles without removing the axle from the frame if the following procedure is followed, and use is made of the special extractor designed for this purpose by Morris Motors Ltd., and obtainable from their spare parts department under Part No. 55418.

The front wheels should first be raised clear of the ground and a firm stand placed under the axle.

The wheels should next be removed, and the brake drums withdrawn after their three retaining countersunk-headed screws have been unscrewed.

Remove the hub-retaining nuts from the ends of the axles, remembering that the offside nut is screwed with a right-hand thread but that the nearside nut is provided with a *left*-hand thread, and therefore has to be unscrewed in the opposite direction to normal. This will release the lock washers, and allow the felt oil-retaining washers to be withdrawn also.

A standard hub extractor should now be utilised to withdraw the hub from the axle, complete with the bearings distance-piece and inner oil retainer.

The brake backplates, complete with shoe assemblies, should now be removed by extracting the split-pins and nuts from the steering bolts, together with the nuts and spring washers from the bolts attaching the backplate to the axle flange.

The brake backplates should be carefully removed and placed on the ground in such a way that the Lockheed hydraulic brake pipes are not twisted or strained. There is no necessity to disconnect the pipes if the backplate assembly is handled carefully, and some support for the backplate may be found advisable.

Remove the nuts from the steering-pin cotters and withdraw the cotters. Remove also the $\frac{3}{16}$-in. setscrew and dust cap from the upper end of the pin.

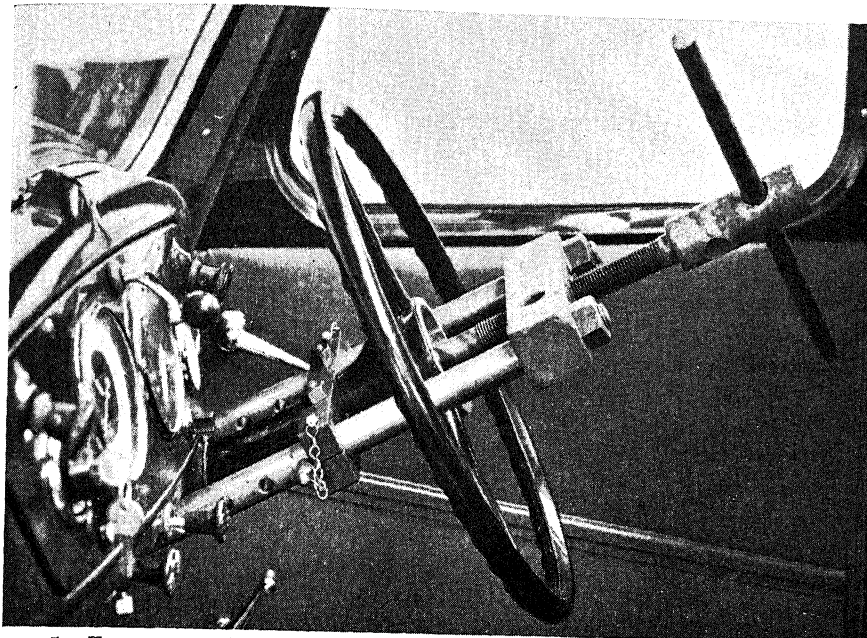
The special extractor should now be placed in position on the top of the steering pin, so that the pin may be pushed out in a downwards direction.

Driving out the pin in this way will automatically force out the dust caps from the bottom end of the steering pin, and these should be retained for refitting on reassembly.

The bushes in the axle are easily removed when necessary either in a suitable press or by the usual method of partly sawing through them, but when replacements are fitted it is essential that they should be reamered out with the special Morris reamer, Part No. 67193, to ensure a proper fit, as the act of forcing them into position contracts them slightly.

Removing the Steering Wheel

The steering wheel is removed from the steering column by releasing the cables from the bottom steering gearbox cover, as described in the



5.—THE SPECIAL MORRIS EXTRACTOR IN POSITION FOR REMOVAL OF THE STEERING WHEEL

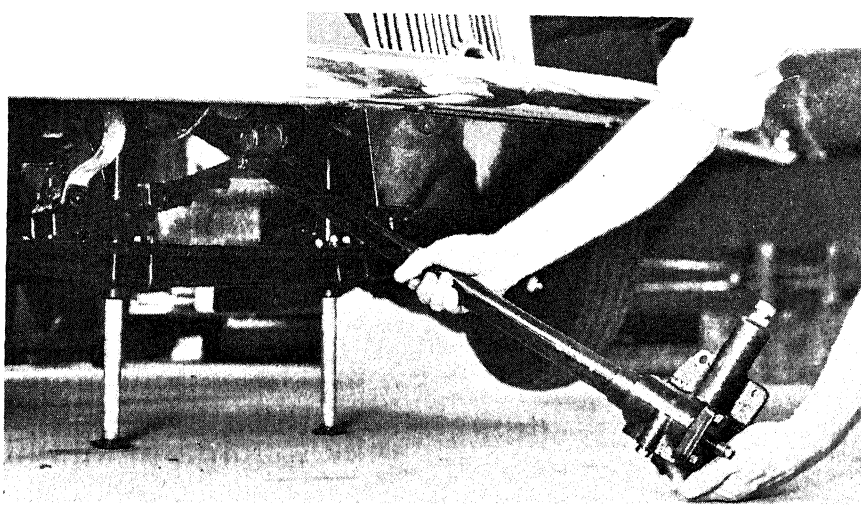


Fig. 6.—REMOVING STEERING-COLUMN ASSEMBLY

When released and the steering wheel removed, the steering gearbox and column can be withdrawn forwards and downwards, as indicated, if the rocker shaft is turned towards the nearside of the car.

section on "Balancing the Trafficator Switch" (*see* Vol. IV.), and driving the stator tube into the car some 2 or 3 in. in the same way.

This enables the cheese-headed clamp-screw of the switchbox to be released, enabling the switch assembly complete with cables to be withdrawn from the stator tube.

The stator tube is then pushed back into the steering column, and the steering-wheel retaining nut is removed with a box spanner.

A suitable extractor should now be employed to withdraw the steering wheel from the column, and that already described for steering-pin removal is quite satisfactory, namely, the special Morris extractor Part No. 55418 when used with the special steering-wheel attachment Part No. 56052.

Replacement of the parts is effected in the reverse manner to their removal, using a draw wire to pull the cables through the stator tube and making sure that the trafficator switch is correctly set, as indicated in the section dealing with this item.

Removing the Steering-column Assembly

The trafficator switch, switch cables, and steering wheel should first be removed, as indicated in the sections dealing with these operations, not forgetting to disconnect the battery positive terminal.

Remove the supporting bracket for the columns from the dashboard by unscrewing the two nuts from the attachment bolts.

Remove the pinch-bolt passing through the slotted end of the drop arm, and withdraw the drop arm from the steering gearbox spindle.

Unscrew the two setscrews attaching the gearbox to the underside of the offside dumb-iron, and the two which pass through the front-spring bracket.

This releases the steering-column assembly, which can now be pushed upwards into the body a sufficient distance to allow of its rotation so that the rocker shaft points towards the nearside.

The complete steering-column assembly can now be lowered again and withdrawn from the front end of the car if it is raised a short distance from the ground.

When reassembling the drop arm on replacement do not forget to make quite sure it is replaced correctly on the steering gearbox spindle, with the mark on its boss coinciding with the mark on the end of the spindle.

RADIATOR REPAIRS

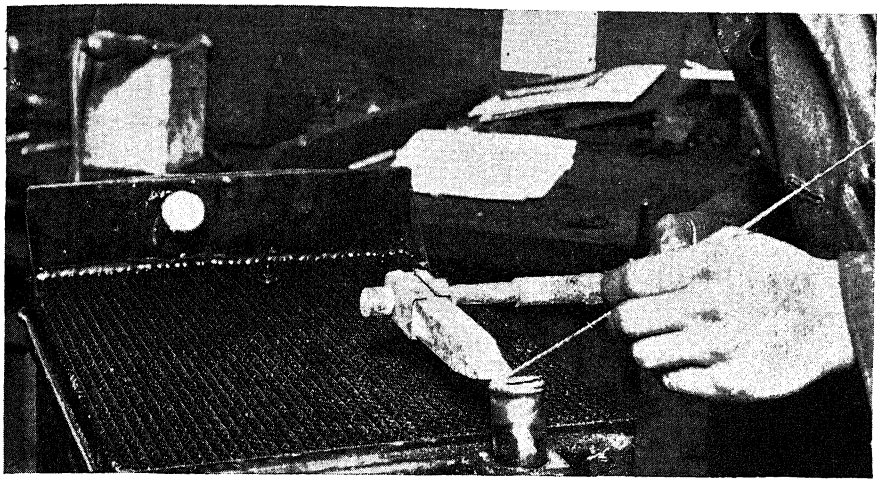


Fig. 1.—To locate leaks it is necessary to make an air-pressure test

The first thing to do is to seal up the water connections by cutting circular discs of tinned iron to the exact size of inlet and outlet pipes and the filler neck and then sweat them on as shown.

THE job of repairing a leaking radiator is one usually handed to a specialist repairer. This would, however, not always be necessary if the owner or garage mechanic were provided with more information concerning the construction of a radiator and the use of the soldering-iron and methods of testing.

Tools Required

It is proposed to deal first with the preparation of the necessary tools required for the job. A clean soldering-iron of an average weight of $1\frac{1}{2}$ lb. is needed. It is useless attempting a radiator repair with the light soldering-iron that one associates with a wireless set, as insufficient heat would be retained.

Tinning the Soldering-iron

The soldering-iron should be thoroughly cleaned by heating to a dull red, and the nose, or face, of the bit filed to the correct shape, i.e. an acute rectangular point with flat sides. The filing under heat is necessary in

order to remove all traces of pitting and saturation of the copper by tin. When the face of the bit is filed perfectly clean and bright, the nose of the bit should be dipped or rubbed in soldering flux or sal ammoniac, a small amount of solder applied from the stick, again dipped into the solution or flux, when a clean tinned face will be obtained. The best solder to use should contain not less than 60 per cent. tin and the remainder lead, usually known as tinman's solder. It is preferable to make use of an electric bit, as the heat being internal and constant the face does not become affected as by heating with gas or with a naked flame. Alternatively, an ordinary bit can be heated over a fire or gas flame to the required temperature.

Testing the Iron

To test the iron, it should run the solder readily without showing a trace of red heat. If an overheated bit is applied to a section of radiator tubes, it is quite within the bounds of possibility to crumple them, as solid copper will retain a far greater heat than the thin tubes of the radiator will withstand.

The Blow-pipe and its Uses

In the hands of a practised mechanic the gas blow-pipe is of great value, as it is almost impossible to repair a leak midway in the tubes with the soldering iron. This blow-pipe must be of such a design as to give a fine gas flame approximately the size of a lead pencil, and of 2 in. or 3 in. in length.

It is not suggested that an amateur should experiment on a radiator, using a flame of this description, without some previous experience. It would not be unusual, if the flame were applied for too long in one place, for a section of the tubes to collapse.

Points to Remember

Two great points to remember when carrying out a repair are, one, that the average thickness of the tubes of most radiators is ·005 in., necessitating somewhat delicate handling, and, the other, cleanliness in the whole operation. Soldering bits, flux, and any small cleaning tools should be perfectly clean. The metal to be soldered must be perfectly clean and free from grease or any foreign matter, otherwise a failure is likely.

TESTING

The method of testing applies to any make of radiator. The radiator, for the purpose of satisfactory test and identification of the leak, should be removed from the car and swilled inside with clean water, preferably warm, to remove silt and lime deposit as much as possible.

How to locate Leaks—the Air-pressure Test

Circular discs of tinned iron, such as can be cut from the average cocoa tin, should be cut the exact size of inlet and outlet pipes and the

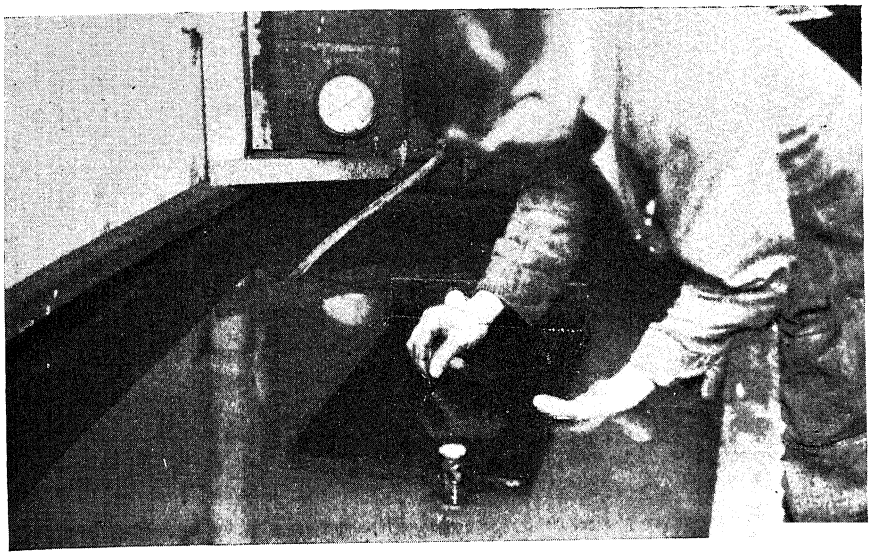


Fig. 2.—THE AIR-PRESSURE TEST BEING CARRIED OUT ON A RADIATOR

A piece of rubber connected to a tyre pump is attached to the overflow and the radiator immersed in a tank of water. Pressure is generated in the radiator, which will then emit bubbles at each of the various leaks. Tiny clips of thin metal should then be pressed over the particular spots where leaks are found so that they can be identified.

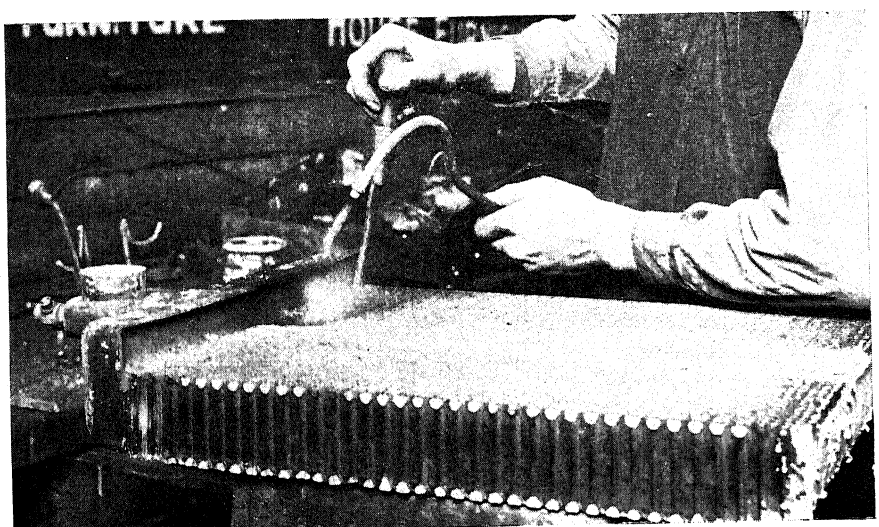


Fig. 3.—REMOVING THE BOTTOM TANK

A gas torch is being used as shown. Great care must be taken to apply the heat exactly and only where required, in order to avoid damaging the soldered joints on the face of the radiator block.

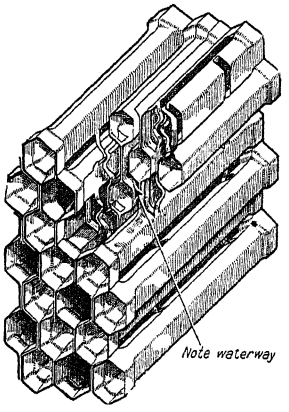


Fig. 4.—SECTION THROUGH HEXAGON-FILM BLOCK

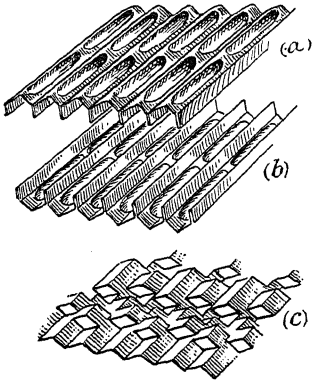


Fig. 5.—SHOWING THE CONSTRUCTION OF THE HEXAGON FILM

(*a*) and (*b*) show brass stamped to form waterway when sealed, and (*c*) cracked brass interleaf.

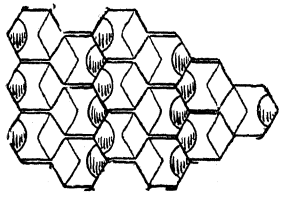


Fig. 6.—END VIEW OF HEXAGON FILM

filler neck: these should then be soundly sweated on. To the overflow should be attached a piece of rubber tube, connected to a tyre pump, and the radiator immersed in a bath or tank of water. By working the pump, pressure will be generated in the radiator, which will then emit bubbles at each of the various leaks. The largest will become apparent first.

Small U-sections of tin or other thin metal can be cut in the shape of tiny clips to be pressed over that particular spot where the leak is identified.

It will be found that when a radiator is leaking badly in many places, it is unwise to attempt to repair more than a few leaks at a time. If it is attempted to identify too many, memory fails in fixing the exact spot.

The Water Test

It is usual, after the radiator passes a satisfactory air-pressure test, to subject it to a hot and cold water test as well. Frequently a tiny crack or fracture in the soldered seam, although not discovered under air pressure, will be evident if the filler-neck cap is removed, the radiator stood in a leaning position, first filled with very hot water, allowed to become thoroughly hot, drained off carefully from the drain plug and immediately filled with cold water, which sets up contraction in the metal, and, if allowed to stand, will then perhaps show further small leaks.

THE FILM-BLOCK TYPE OF RADIATOR

This is the commonest type of radiator. Top and bottom tanks are fitted direct to the tubes, which is known as the core. This has the appearance, when viewed from the front, of a series of sections of corrugated brass placed together to form the necessary shape. A loose demountable shell is afterwards fitted.

At first appearance these corrugated sections appear to be simply one thin sheet of metal, but if closely examined it will be seen they are actually two thin pieces of metal first corrugated, the ends slightly offset, which, when placed together, leave an aperture between, through which the water can circulate.

Some of this type are built into the outer shell in such a manner that the whole, including the shell, is removed as one unit. The centre, complete with top and bottom tanks, can then readily be removed from the shell by removal of a small number of bolts and nuts. It is always advisable to remove the core from the outer shell before even attempting to test, to protect the finish of the shell from scratches or the effect of any solution that may be used in a repair.

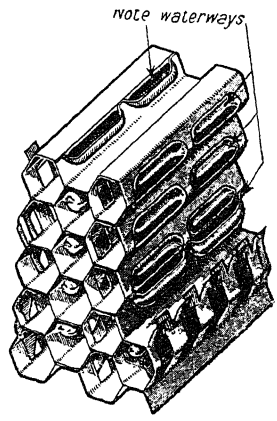


Fig. 7.—SECTION THROUGH FILM BLOCK

Temporary Repair on the Road

In the case of a leak occurring in the plain-film block whilst the car is on the road, it is sometimes possible, if the definite spot where the leak is can be identified in the tubes, to plug between the leaking spot and the neighbouring tube by inserting a thin piece of rubber tube and afterwards pressing into the rubber tube a small piece of wood, cut and shaved to the required shape to a push-in fit. Care must be taken not to exert too great pressure nor to insert the wood without a soft substance between the wood and tubes, or they may become perforated by the wood.

Do not use Putty or White Lead Stopping

In no circumstances is it wise to attempt to plug a section of leaking tubes with putty, white lead, or any substance which hardens, as once this has become solid in the tubes it is practically impossible to remove. Consequently, a new block would eventually be required. Should rubber tube be unavailable, if the radiator is drained, soap can sometimes be used as a plug with satisfactory results, and this can afterwards be quite easily removed by hot water when a permanent repair is to be effected.

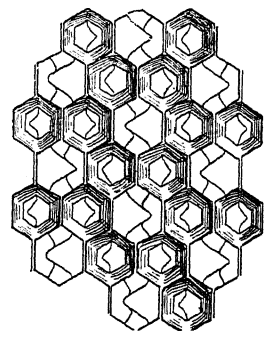


Fig. 8.—END VIEW FILM BLOCK

Method of Repairing Film-block Type Radiators

In a more extensive repair when possibly four or five tubes are affected, it can be decided under test whether the leak is at the joint of the tubes

on the face of the block. If so, these leaks are fairly easily repaired by cleaning thoroughly, applying some of the flux, and using the soldering-iron carefully in the usual manner.

Cleaning

If leaks are in the depth of the block the operation of repair is obviously a more difficult matter. It is fairly easy to clean through the tubes by means of the small wire brush, or even by scraping with the end of a small piece of brass wire. As a gas flame is essential to remedy this defect, it should not be attempted without previous experience of the gas flame.

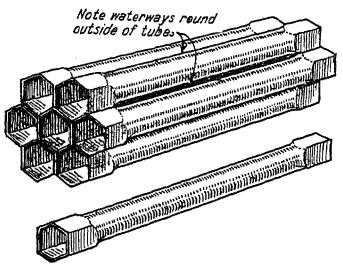


Fig. 9.—HONEYCOMB-TUBE SECTION WITH SINGLE TUBE OF SAME

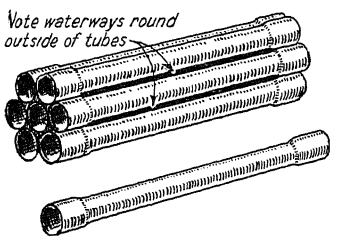


Fig. 10.—ROUND TUBE AND SECTION OF SAME ASSEMBLED

How to Blank Off a Faulty Tube

If it is a matter of urgency and the repair must be made, the easier way is definitely to identify and trace the leaking tubes from the bottom of the block to the top, cutting an opening in the top and bottom tanks sufficiently wide to expose the top and bottom of the tubes. The tubes can be cleaned at the inlet aperture at the top and the outlet at the bottom, and a small piece of brass wire inserted in the aperture, which can then be soldered into position, thereby blanking off the particular tube. This operation must be carried out at both top and bottom to be effective ; if only the top is sealed, the water will find its way up the tube from the bottom and the original leak will still remain.

When it becomes necessary to seal the end of the tubes, rendering them inoperative, it is distinctly dangerous to deprive the radiator of more than 15 per cent. to 20 per cent. of its original cooling capacity.

Subsequent to the sealing of the tube, the holes cut in the top and bottom tanks can easily be sealed by thin brass or copper sheet. On no account must tinned iron be used for this purpose.

If the Leak is between a Water Joint and Tank

Should the leak, on testing, prove to be between the seat of one of the water joints and the tank, this can sometimes be repaired by careful cleaning without the removal of the joint ; but whenever possible it is wise to remove the defective joint, to permit of proper cleaning.

The usual procedure, when the joint is riveted to its tank, is to cut the

existing rivets, replacing them, when the joint and its sealing have been properly cleaned and tinned, by small brass thread screws and nuts of an appropriate size.

To attach the nuts to the ends of the screws when passed through the holes in the joint, in some cases it is possible, where the joint is straight and large enough, lightly to sweat the nut to a piece of wire, passing it through the joint to its required position, when the screw can be inserted. The joint should then be heated, to run solder at its seating, and sufficient added to make a strong joint.

In the case of a water joint of an awkward shape it is usual to cut a small hole in the tank of the radiator in a convenient position, just large enough to allow the nut when attached to the piece of wire to be passed through. When attached to its screw and pulled tight it will be found easy by a twisting motion to detach the wire from the nut. These small holes can afterwards be sealed.

Dealing with a Faulty Overflow Pipe

One curious complaint that occasionally develops is the inability of a radiator to maintain its water level above a certain distance below the top of the overflow pipe.

If this is the case, it can usually be accounted for by a perforation, split, or crack in the overflow pipe below its top level and before it emerges from the tank. The only cure is to remove the pipe, which is a straightforward job, and replace by sweating in a new one, or by sweating or soldering the crack. Care should be taken when fitting a new overflow pipe or replacing the old always to attach the water-level end to the inside section of the filler neck. This can be effected by inserting the soldering-iron through the filler neck or by the application of a small flame. The outlet end should also be attached to some section of the block to prevent vibration. Either end left loose will vibrate and leak within a short time where soldered to the tank.

THE INTERLEAVED-FILM BLOCK TYPE

The interleaved-film block is built up in exactly the same manner as the plain-film block, with the addition of a thin, flat, copper strip inserted between each tube. This has the effect of increasing the efficiency of a cooling element by about 15 per cent.

It is somewhat more expensive to produce and, owing to the thin strip of copper between each set of corrugations, becomes somewhat more difficult to repair.

The method of repairing is exactly the same as for the plain film, but requiring somewhat more skill.

HONEYCOMB CRACKED INTERLEAVED-FILM BLOCK TYPE

This block is a film-tube block, but, when viewed from the front, has the same appearance as the older type of honeycomb proper, and was first produced in America. It has been manufactured in this country for some years and has become popular.

Repair

The finished article has a better appearance than the plain or the interleaved film and has excellent cooling efficiency, but is considerably more expensive to manufacture and more difficult to repair. Owing to its peculiar construction the repair of this particular block when leaking is not recommended for any but an expert.

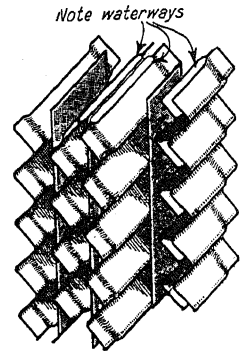


Fig. 11.—SECTION THROUGH SERCK INTERLEAF DIAMOND FILM

Testing

The method of testing is exactly the same, and repairs can be made in the same manner as in a plain-film block. Identification of a leak is rather more difficult owing to the corrugated interleaving, which is cracked and corrugated in two directions.

This block has an excellent record in durability unless subjected to external impact or ill-usage.

THE VERTICAL-TUBED BLOCK TYPE

Of this there are various types. The one most likely to be the subject of repair is the straight, horizontal-grilled, vertical-tubed type.

Construction

This type is composed of a top and bottom plate, perforated with holes the size of the tube to be inserted, and an appropriate number of tubes the length that the height of the block is intended to be are then inserted. Before insertion in the top and bottom plates, a series of thin copper, or in some cases iron, sheets perforated in a like manner are threaded to the nest of tubes, which then have the top and bottom plates attached, being properly tinned and sweated.

Locating a Leak

The radiator of this description, when leaking, should be the subject of the usual test. Evidence of the leak will become apparent in the same manner. If in the tubes, it will be necessary to separate the horizontal gills by means of a screwdriver to ascertain the exact spot where leaking, which can then readily be cleaned, tinned, and easily soldered.

A Caution

If the leak is between the tube and its top and bottom plate at the joint, it is unwise to attempt to repair this from the outside, as, although outside repairs of this nature possibly prove temporarily successful, the heat applied to the particular leak impoverishes the solder of the surrounding tubes to such an extent that in a short time the leak may become magnified.

Method of Repair

If it is intended only to repair one tube, a section should be cut from the tank and the tube repaired from the inside. If it is intended to resolder the whole of the tubes over one plate, the tank should be removed by unsweating at the seams, when the whole of the tubes and plates through which they pass can be cleaned and resoldered.

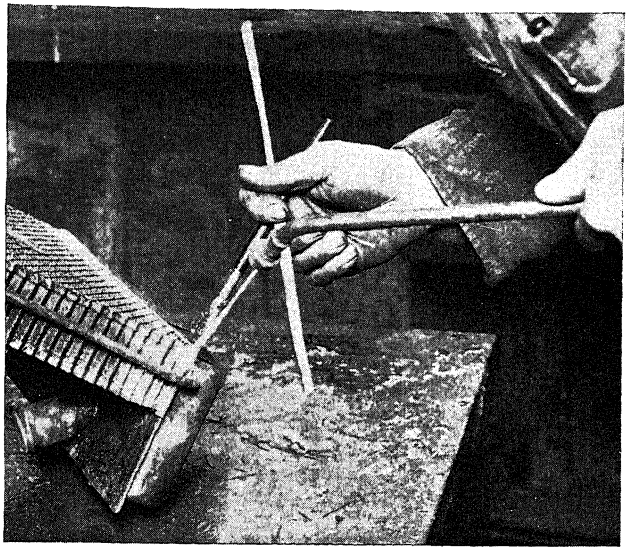


Fig. 12.—FITTING A TOP TANK
Showing how use is made of a gas blow-pipe.

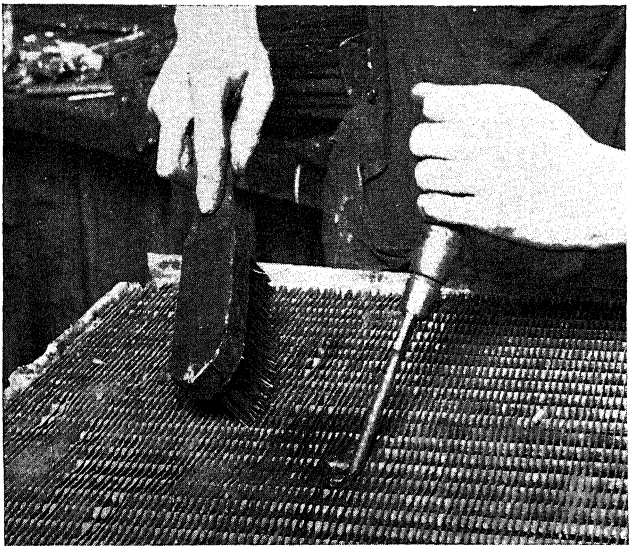


Fig. 13.—OPENING THE GILLS OF A VERTICAL-TUBE BLOCK

If a leak is found in the tubes it will be necessary to separate the horizontal gills by means of a screwdriver to ascertain the exact spot where it is leaking, which can then readily be cleaned, tinned, and soldered.

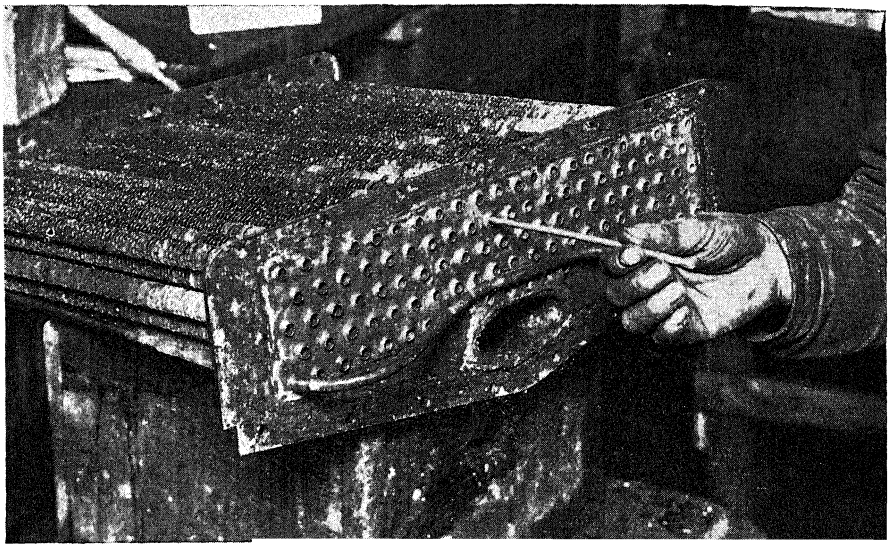


Fig. 14.—WHERE A VERTICAL TUBE IS LARGE ENOUGH AND HAS BECOME FRACTURED IT IS SOMETIMES FOUND EASIER TO FIT A LENGTH OF TUBE THROUGH THE ORIGINAL TUBE AS A LINER, SWEATING IT UPON THE PLATE AT EITHER END

This becomes necessary only where it is impossible to remove the damaged tube, or when a new tube is unobtainable. This makes a much more satisfactory job than blanking off the damaged tube.

In the case of demountable top and bottom tanks, which are usually of cast aluminium bolted to a fairly substantial plate, these can be removed without any damage occurring by the removal of the holding bolts ; the tubes are then accessible.

There are various types of vertical tubes in addition to the straight horizontal gill. Some are fitted with square gills stamped from small sections of thin tinned iron. There are also round and spiral gilled tubes. The manner of repair of these is the same.

Fitting a Liner inside a Damaged Tube

Where a vertical tube is large enough and has become fractured, it is sometimes found easier to fit a length of tube through the original tube as a liner, sweating the same upon the plate at either end. This becomes necessary only where it is impossible to remove the damaged tube, or when new tube is unobtainable.

The individually gilled tube is more generally used on heavy commercial vehicles.

THE HONEYCOMB-BLOCK TYPE

Of this block there are various types—round, hexagon, and square—in appearance resembling the honeycomb, doubtless from which this type

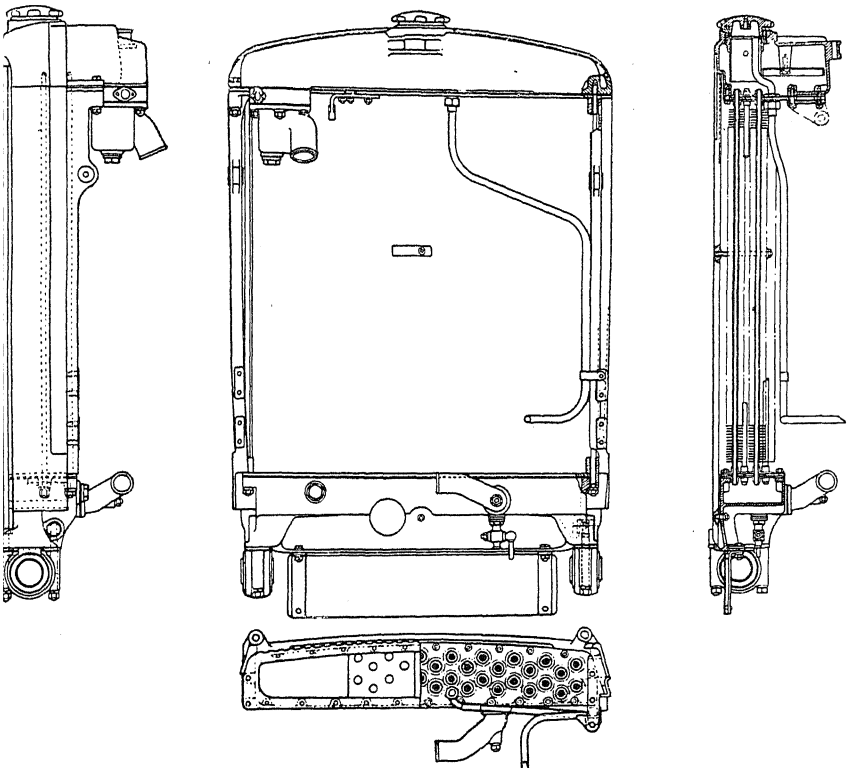


Fig. 15.—VERTICAL-TUBE TYPE OF RADIATOR (*A.E.C.*)

derived its name. At the time of its introduction it was the best and most efficient radiator. Owing to the cost of production it has become more or less obsolete, except in some of the more expensive cars.

Construction

This block is composed of a series of small drawn-brass tubes, in length the thickness of the block. Each tube has its end slightly expanded ; for assembling, the tubes are built into a frame closely packed side by side. When the frame is packed to completion it is clamped tight to the tubes, which are then dipped into a molten bath of solder on both faces, soldering the end of each tube to its surrounding neighbours.

The finished block is built into its tanks in exactly the same way as the film block if fitted to a demountable shell.

Method of Testing and Repair

For the purpose of repair the method of test is exactly the same as for the film or vertical tubed type. The identification of a leak is a rather

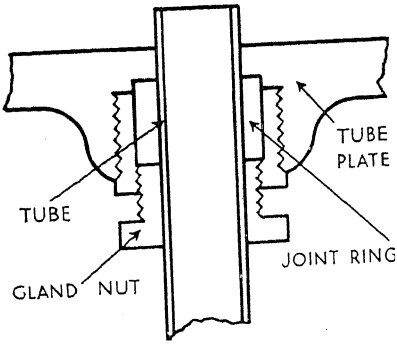


Fig. 16.—SECTION OF TUBE-GLAND OF RADIATOR IN FIG. 15

Leakage at the gland can be remedied by either tightening down the gland nut or, if this is not effective, by replacing the rubber gland.

more simple matter. Marking is made in the same way as for the film type; the difference is in the repair.

Should a surface leak be apparent by the application to the leaking spot of a soldering flux and careful cleaning, a repair can usually be effected in a short time with a copper bit. If it happens that a tube has become burst by frost, or perforated by the application of a heated soldering-iron to either end of the tube at the same time, or the flame of a fine gas blow-pipe blown through the tube, the defective tube can usually be removed and replaced by a new one, which is easily sweated in.

Owing to the scarcity of these radiators and the credit which must be given to them for durability and efficiency, the likelihood of a repair becoming necessary is rather remote.

One curious difference between the film or vertical tube and the honeycomb tube is that in the film or vertical the water passes inside the tube; in the honeycomb it passes outside. When viewing the honeycomb block from its face one is actually looking through the inside of the tubes.

STRAIGHTENING, CHECKING, AND ALIGNING FRONT AXLES

THE influence on the steering performance of a front axle out of alignment through even a slight impact is dealt with in Vol. I, under " Diagnosing and Correcting Steering Troubles." Where any doubt exists, this alignment should be checked. If difficulty is experienced in making these checks with the front axle in position, it will be necessary to remove the axle from the chassis, in order to check for alignment. On the other hand, a front axle may have been damaged to such an extent that the mal-alignment is quite apparent.

Removing Axle from Chassis

The fixing is usually obvious, the usual attachment being by the means of U-clips forming a yoke across the spring, passing through the tables of the axle, fitted with locknuts, nuts, and spring washers, or split pins, each of which are quite visible and easily removed.

The chassis frame must first be raised sufficiently high to take all weight off the front wheels, and securely supported in that position, the front wheels removed from the axle, and boxes or other supports placed in a convenient position so that when the U-bolts are completely released, the axle does not fall to the ground.

Attention is required to the braking system, as this must also be detached. With direct or servo braking, the detachment is an easy matter. With Lockheed brakes, the tubes should be carefully detached and the ends tied upwards to prevent as little of the fluid becoming wasted as possible.

The axle can then be entirely removed and placed in a vice or on a bench for examination and checking.

Before placing in the vice, the unit should be first thoroughly washed and cleansed of all mud, grease, etc., in a paraffin bath.

Dismantling the Axle

It is difficult to check a front axle without dismantling the brake gear, and it is always advisable to dismantle entirely, removing the brake gear and the king-pins.

Checking the Stub Axle

Whilst dismantling, if a king-pin appears unduly tight, the yoke of the stub axle should also be carefully examined, and when possible the

stub axle placed between centres or V-blocks to check the truth or otherwise of the spindle.

If Axle Beam is obviously Bent

The axle beam is next given attention. At the end of this article, the methods of finally checking the alignment of the axle beam are given. These methods can now be applied to the beam to find the amount of correction required. With a beam that is bent badly enough to be obvious, it will be unnecessary to commence testing until some straightening has taken place. Axles that are badly bent are often damaged to such an extent that straightening is not advisable, in which case it is always better to advise the owner to have a new axle fitted.

Correct Angle of King-pin Holes

For the purpose of ascertaining the correct angle of the king-pin holes, it is always best to make use of a makers' chart if obtainable. It seldom occurs, however, that both side angles become distorted—usually one is obviously unaffected. The angle of this side should be recorded by a protractor before any heat or straightening is applied.

Straightening Bent Axle Beam

The bend should be located carefully and chalk-marked at each extreme, an anvil or weight prepared upon which the beam is to be placed when heated, and a strong vice securely fixed in such a position that it is accessible and well lighted. The affected part of the beam should be heated to not more than a dull-red heat, placed in the vice, and forced by pressure to its correct shape. Should a press be available for this operation, its utility can be fully understood. So far as possible, blows with a sledge-hammer should be applied with great care. The heating should not exceed a dull red—just sufficient to allow the metal to be straightened.

First bring Spring Tables into Alignment

If the unit is affected between the spring tables, as well as between one spring table and a king-pin hole, straightening should commence from the centre, first bringing into correct alignment both spring tables, dowel-pins, and U-bolt holes. When checking the U-bolt holes it will be necessary to examine the front-spring alignment to find if the springs are parallel or have a taper fitting. The amount of taper can be ascertained by measurement, comparing the difference in width of the front knuckle joints and the rear shackles where the front springs are anchored to the chassis frame and working out geometrically the angle of the spring tables.

Then Straighten and Align Axle End Extension

The alignment of the tables must be carefully carried out and proved before proceeding to straighten the axle-end extension. When this

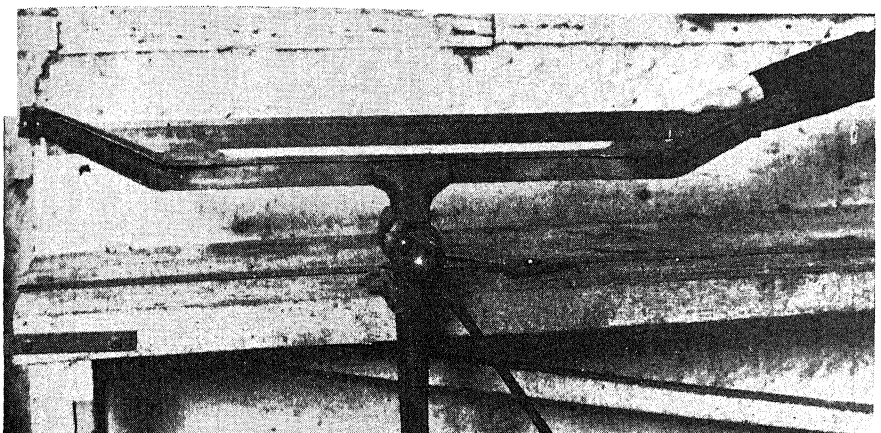


Fig. 1.—THE FIRST CHECK FOR ALIGNMENT
A straight-edge placed across the spring tables should lay quite plane.

operation has been completed satisfactorily, place the axle in the vice and ascertain the exact treatment that is required to restore the defective extension to proper alignment. To do this, a straight-edge placed across both spring tables and a trammel rod fitted to both king-pin holes, a protractor set to the unaffected side and then tried to the bent section, will indicate the amount of correction required to bring into alignment. A sight-line taken across the trammels will reveal any defect in vertical alignment. This will enable the operator to gauge more correctly the amount of pressure required to restore the affected part to normal.

Treatment after Straightening

When the beam has been restored to satisfactory alignment, it should be heated generally throughout and laid in ashes or sand to prevent chilling, and allowed to cool gradually and evenly, and never quenched in water.

A Word with Reference to Heat-treated Axles

It is a modern manufacturing process to subject front axles to a special heat treatment in order to toughen the metal and increase its tensile strength.

An axle so treated should, when possible, be returned to the makers to be subjected to their special method of heat treatment. Although a previously heat-treated axle may be satisfactorily straightened, there is an element of risk that in a subsequent impact a fracture may occur, or the nature of the metal may become impoverished and soft. Heat-treated axles can invariably be recognised by having a small section usually

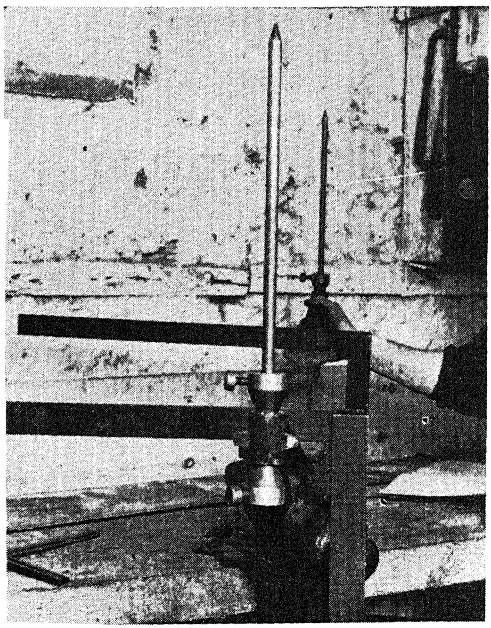


Fig. 2.—CHECKING ALIGNMENT OF SPRING TABLES AND KING-PIN HOLES

The horizontals of spring tables are checked by sighting the tops of the two straight edges with a square laid across each. This also shows checking verticals of king-pin holes by inserting special rods with taper sockets attached and sighting from end of axle beam.

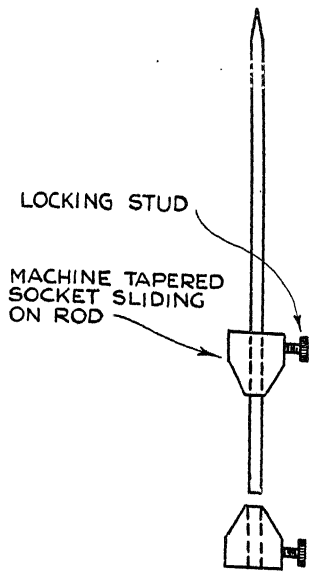


Fig. 3.—KING-PIN TRAMMEL OR TESTING PIN

The sockets which slide on the rod are conical to bring the rod central in king-pin hole when sockets are pushed together and studs locked.

in the beam between the tables ground flat and several small round marks driven in. These marks are inflicted under the Brinell test to which the axle is subjected by the manufacturers after heat treatment. As mentioned on page 312, it is safe to straighten axle beams cold if the metal has not been stretched to any extent. A magnetic tester will immediately show up any incipient cracks or flaws which may exist (*see* Figs. 22 and 23, pages 310 and 311).

Straightening a Slightly Bent Beam

A slight bend in a light-car front-axle beam can be rectified without the application of great heat, and can be straightened without disturbing the effect of previous preheating.

It is always necessary to remove the chill from the metal throughout the whole length of the beam, including spring tables and king-pin sockets. Preferably, the necessary pressure should be applied by a press.

If, however, a press is not available, by careful blows with a sledge-hammer and the beam placed on an anvil the rectification can be effected satisfactorily. In order to preserve the surface of the metal before striking with the hammer, place upon the affected spot a blacksmith's set hammer if procurable, or an ordinary piece of bar-iron to take the blow—which will prevent bruising of the surface.

Defective Stub Axles

When dismantling the stub-axle ends, if one king-pin is troublesome to remove and much tighter than its opposite member, it is possible that the yoke has become damaged. This defect is not one that can easily be rectified, and a replacement stub axle can safely be recommended.

Where damage to a stub axle has been sustained by impact on a wheel or hub centre, the spindle should be tested as recommended, and if found defective, provided the defect is only of a slight nature, can sometimes be satisfactorily straightened by a skilful operator. This operation, however, requires powerful and accurate machines, and should not be undertaken except under exceptional circumstances. It is not in any case advisable if a replacement unit can be procured economically.

Defective King-pins

When a stub axle is proved to be bent in the yoke, it will be obvious that the king-pin will also be affected. The pin has invariably a ground and polished finish, and is case-hardened ; it can confidently be recommended that bent king-pins should under no circumstances be straightened and put into service.

It is a good practice before erecting a renovated axle to examine the king-pins and stub-axle spindles, although apparently undamaged, for possible cracks. These parts, being bright, after being thoroughly cleaned and immersed in paraffin, then removed from the paraffin bath, wiped dry, and cleaned with a petrol rag to render the surface of the metal dry and bright, will, if smartly tapped with a mallet or light hammer, reveal cracks, if any exist, by exuding paraffin which has penetrated into them.

FINAL CHECK OF FRONT-AXLE BEAM BEFORE ERECTING

The surface of the spring tables, vertical alignment of the king-pins, and the angles of the pins must all be carefully checked and proved correct before commencing to reassemble the axle. Checking may be done in the following manner :

Spring Tables

Place the axle again in the vice, laying a long straight-edge lengthwise across both spring tables at the same time. Look between the straight-edge and the spring tables with the eyes at the same level, holding a sheet of white paper behind the straight-edge, which will render any error in alignment visible (Fig. 1).

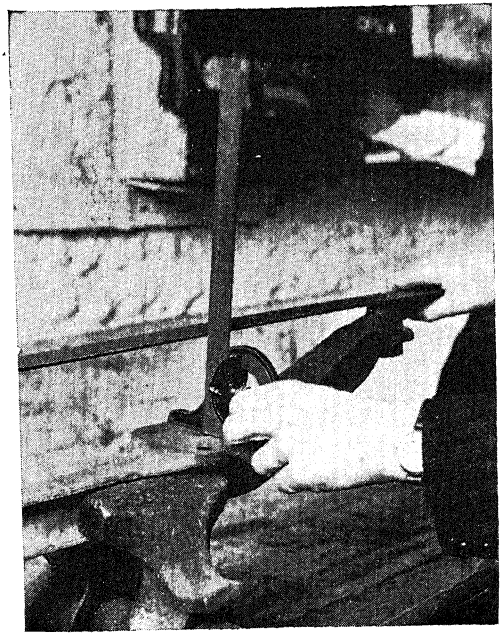


Fig. 4 (*left*).—TESTING ALIGNMENT OF KING-PIN AND DOWEL-PIN HOLES

Straight-edge laid flat and set at centre of king-pin holes. Protractor set at 90° touching straight-edge with square point at centre of dowel pin hole.

Next, take two shorter straight-edges or squares of a sufficient thickness to support themselves and lay each crosswise over the spring tables, taking a sight-line from the end of the axle to check the horizontal alignment of the tables (Fig. 2). Subject to this test proving satisfactory, proceed with the check.

Axle-end Extension and Dowel- and King-pin Holes

Place the long straight-edge across the top of both king-pin sockets, taking a measurement down from the lower edge of the straight-edge to the centre of the spring table to prove the rise of the axle extension between the spring table and the king-pin socket (Fig. 6). Next, turn the straight-edge flat on to the king-pin socket with one edge across the centre; place a small square on the spring table, with its edge to the centre of the dowel-pin

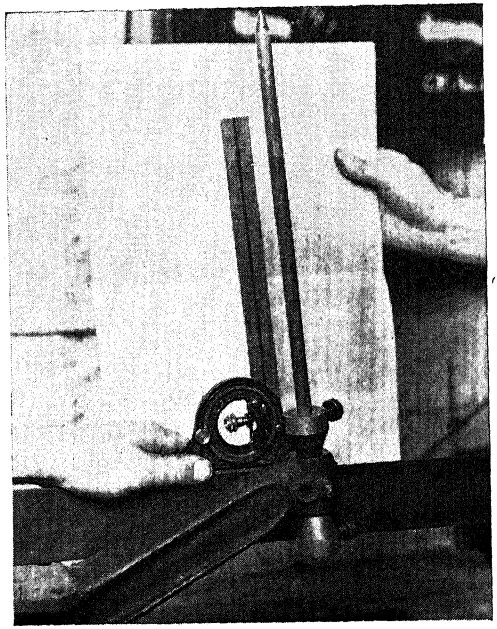


Fig. 5 (*left*).—TESTING ANGLE OF KING-PIN HOLE

First set protractor at correct angle, place straight-edge across both tables and insert rod through king-pin hole. The protractor is placed on the straight-edge and white paper is held upto throw edges into greater relief.

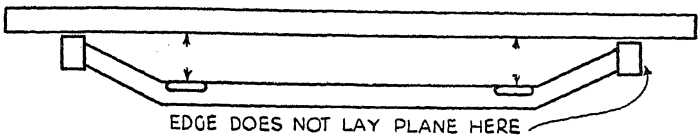


Fig. 6.—MEASURING RISE OF EXTENSION FROM SPRING TABLE TO KING-PIN SOCKET.

The straight-edge does not, of course, lay flat on top of the socket, owing to the angle at which the pins are set.

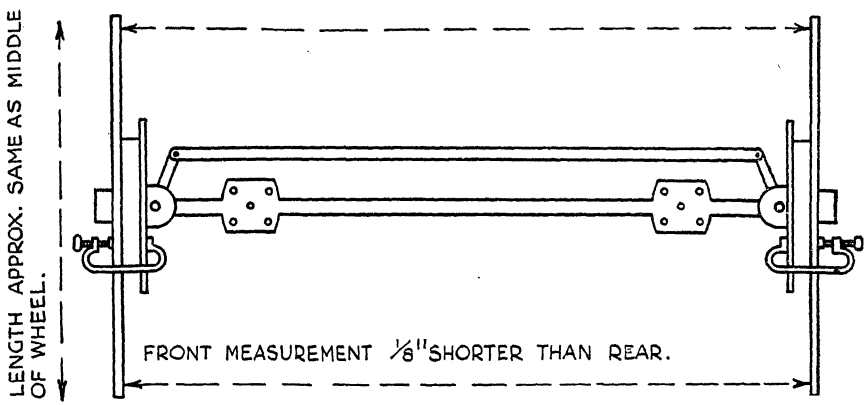


Fig. 7.—CHECKING FRONT-WHEEL ALIGNMENT BEFORE FITTING AXLE TO CHASSIS BY CRAMPING STRAIGHT-EDGES TO FACE OF HUBS AND MEASURING EACH SIDE.

The above example indicates a toe-in of $\frac{1}{8}$ in.

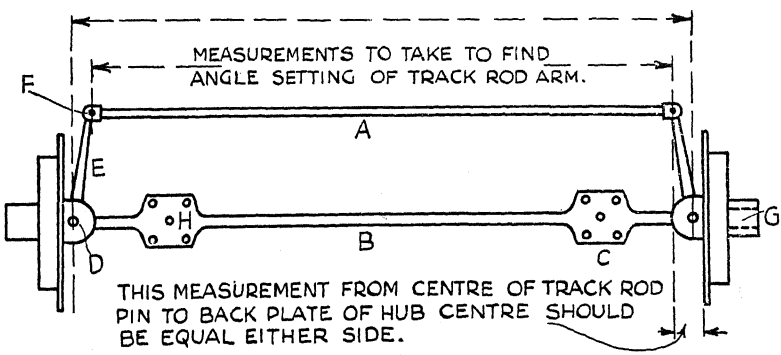


Fig. 8.—LAY-OUT OF TYPICAL FRONT AXLE.

A, Track rod. *B*, Axle beam. *C*, Spring table. *D*, King-pin. *E*, Track-rod arm. *F*, Track-rod pin. *G*, Stub axle. *H*, Dowel-pin hole.

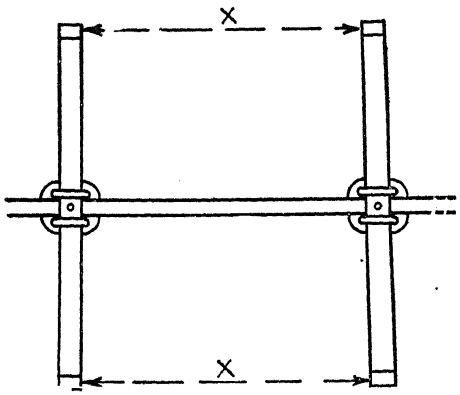


Fig. 9.—PLAN OF FRONT SPRINGS

Set at an angle to show measurements to take to ascertain angle at which spring tables should be.

hole, to prove that the centre of the dowel-pin holes and the king-pin holes are in alignment (Fig. 4).

Angles of King-pin Sockets

Finally, but not the least important, is a determination of the angles of the king-pin sockets. This must be checked from two positions, the spring table and the socket itself. Place the trammel bars securely in the sockets, lay the long straight-edge lengthwise across the spring tables, set the protractor to the axle end which was unaffected, taking care that this setting is correct, using the sheet of white paper to throw the line of the trammel bar into greater relief, and, when a maker's chart is available, the degree of angle should be carefully registered and checked against the chart (Fig. 5).

Reverse the protractor and place in the same position on the opposite side of the beam to test the angle of its fellow-member.

To ensure accuracy, then place the straight-edge across the top of the king-pin sockets and check the angles again by the same method. If this is incorrect, it indicates that the rise of the extension is not right.

REASSEMBLING

After accidental damage and the subsequent restraightening of a front-axle beam, it is assumed that prior to the damage the front-wheel track was in normal alignment. When commencing to reassemble the repaired parts, they should re-erect freely and without undue force, each part being greased and carefully lubricated during the operation. If force is necessary to any parts, these parts should be the subject of careful examination.

Checking Track-rod Arms

Before refitting to the car, the condition of track-rod arms needs attention. These parts are subject to fracture and damage which may easily escape detection. All paint should be removed and the arms scraped clean and tested for cracks in the manner recommended for king-pins and stub axles. When proved undamaged and reassembled in position, the track rod should be carefully examined and track-rod pins subjected to the same inspection.

It is modern practice to fit straight track rods which are at times

provided with an adjustment. This adjustment is not intended to overcome malalignment, but to correct minor errors of a fractional nature.

Preliminary Checking of Front-wheel Alignment

With the axle fully assembled, the front-wheel alignment can be checked before fitting to the chassis, as it may be necessary to make some alteration in the setting of a track-rod arm. Completely assemble the unit less the front wheels only. Retain the beam firmly in the vice, take two sections of wood approximately the length of the diameter of the wheels, and cramp or fix them to the hub firmly across the face, balancing them in such a manner that they remain in a horizontal position. Set both hubs parallel, in the position they would be if attached to the car and steering straight ahead, taking an exact measurement between the rear end of each wooden straight-edge and comparing with the front (Fig. 7)

Usually, where the parts are in good condition with no visible wear, the frontal measurement should read not more than $\frac{1}{8}$ in. short. If this measurement is abnormal, the track-rod arm attached to the damaged side should be carefully examined. The position of a track-rod arm is not in any sense haphazard, and has a direct relationship to the angle upon which the wheels turn when on the lock. Measurements taken from the track-rod pin hole in the arm to the brake-drum cover will usually reveal a discrepancy and indicate which arm is at fault—each side should be exactly equal.

Alternatively, take a measurement between the centres of the king-pin holes and another between the centres of the pin holes in the track rod, which will be found the shorter of the two. Divide this measurement equally on each side, and the degree of angle on each track rod compared with the stub axle can be confirmed.

Setting of Track-rod Arm

The setting of a track-rod arm should be carried out with the same care as an axle, and as little heat as possible is applied. These parts are as important and susceptible to fracture as any part of the unit, and should therefore be treated with the same care and attention as any other.

Subject to the axle passing the recommended examination and test, the next operation is to refit to the chassis frame.

Refitting Axle

No special attention is required when refitting an axle to a car fitted with direct or servo braking system except to make sure that all bolts are in good condition, well tightened, fitted with strong washers or split-pins, and that the brakes are adjusted in the usual manner.

With the Lockheed system of braking, the brakes will need bleeding. This operation must on no account be overlooked. It is quite a simple

operation provided the operator has the proper bleeding nipple and tube for the purpose. (*See* section on "Lockheed Brakes.")

Check Wheel Alignment

Finally, attach the wheels and spin them to ascertain that the brakes are free and that the wheels have suffered no damage and are running true before removing the supports and placing the car upon the ground. Also, check the front wheels for alignment, taking measurements between the fronts of each rim and between the rears by the means of trammels specially designed for the purpose, setting the trammels carefully as near to the centre of the wheel as possible, chalk-marking the rim where checked, passing the trammel underneath the car at the rear of the wheels, slightly raising the wheels from the ground, turning over until the chalk marks are in the same position in relation to the trammel as they were when checking the front. This test should give the same reading as the alignment test before fitting the axle.

Testing Lock

Next, raise the front wheels clear of the ground, turn on to one extreme lock, taking a measurement from the inside of one rim to a chassis-frame front knuckle, reverse on to the opposite lock and take an opposite measurement, which should coincide within $\frac{1}{2}$ in.

If this measurement is unsatisfactory, an adjustment can invariably be made by setscrews provided for the purpose.

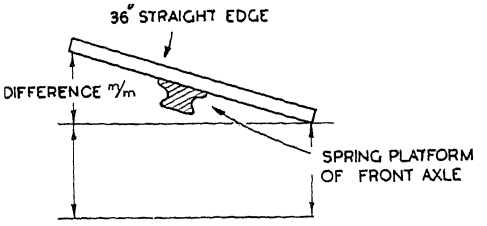


Fig. 10. (*left*)—THIS SHOWS A METHOD OF CHECKING THE CASTOR ANGLE OR BACKWARD INCLINATION OF AXLE AND KING-PIN.

The straight-edge must be 36 in. long, but need not be centralised on the spring platform. After the measurements have been taken, the angle can be obtained from the table below.

STUB-AXLE-PIN INCLINATION

Difference mm.	*Angle deg.*	*Difference mm.*	*Angle deg.*	*Difference mm.*	*Angle deg.*	*Difference mm.*	*Angle deg.*
4·00	$\frac{1}{4}$	43·18	$2\frac{3}{4}$	82·35	$5\frac{1}{4}$	121·36	$7\frac{3}{4}$
7·85	$\frac{1}{2}$	47·10	3	86·25	$5\frac{1}{2}$	125·22	8
11·73	$\frac{3}{4}$	51·20	$3\frac{1}{4}$	90·17	$5\frac{3}{4}$	129·14	$8\frac{1}{4}$
15·70	1	54·94	$3\frac{1}{2}$	94·07	6	133·02	$8\frac{1}{2}$
19·62	$1\frac{1}{4}$	58·36	$3\frac{3}{4}$	97·98	$6\frac{1}{4}$	136·90	$8\frac{3}{4}$
23·57	$1\frac{1}{2}$	62·84	4	101·88	$6\frac{1}{2}$	140·76	9
27·48	$1\frac{3}{4}$	66·69	$4\frac{1}{4}$	105·78	$6\frac{3}{4}$	144·66	$9\frac{1}{4}$
31·38	2	70·61	$4\frac{1}{2}$	109·68	7	148·54	$9\frac{1}{2}$
35·08	$2\frac{1}{4}$	74·52	$4\frac{3}{4}$	113·58	$7\frac{1}{4}$	152·66	$9\frac{3}{4}$
39·25	$2\frac{1}{2}$	78·43	5	117·47	$7\frac{1}{2}$	156·28	10

THE VAUXHALL FOURTEEN (MODEL "J")

WITH FURTHER NOTES ON THE TEN AND TWELVE

To Remove Radiator and Front-wing Assembly

WHERE it is necessary to remove the radiator and/or wings for attention to other parts of the car, a saving of time can be effected by the removal of both wings and radiator as an assembly on the Vauxhall Fourteen (model "J"), Ten-Four (model "H"), and Twelve-Four (model "I").

This is done in the following manner on the Fourteen, the procedure on the other models mentioned being almost the same. *Take care while doing so not to damage the front-brake hoses.*

Drain off the water from the radiator and disconnect the hoses. Remove the bonnet. Disconnect the side- and head-lamp leads at the push-in connectors on the right-hand wing valance.

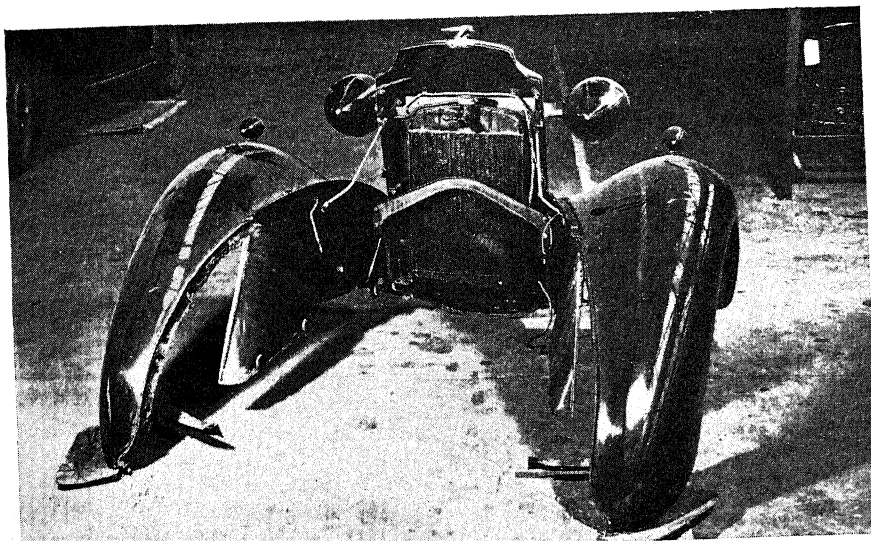


Fig. 1.—BOTH WINGS AND RADIATOR CAN BE REMOVED AS AN ASSEMBLY ON THE VAUXHALL 14 H.P., 12 H.P., AND 10 H.P.

The example shown is the assembly on the Ten-Four car.
(*By courtesy of Shaw & Kilburn, Ltd.*)

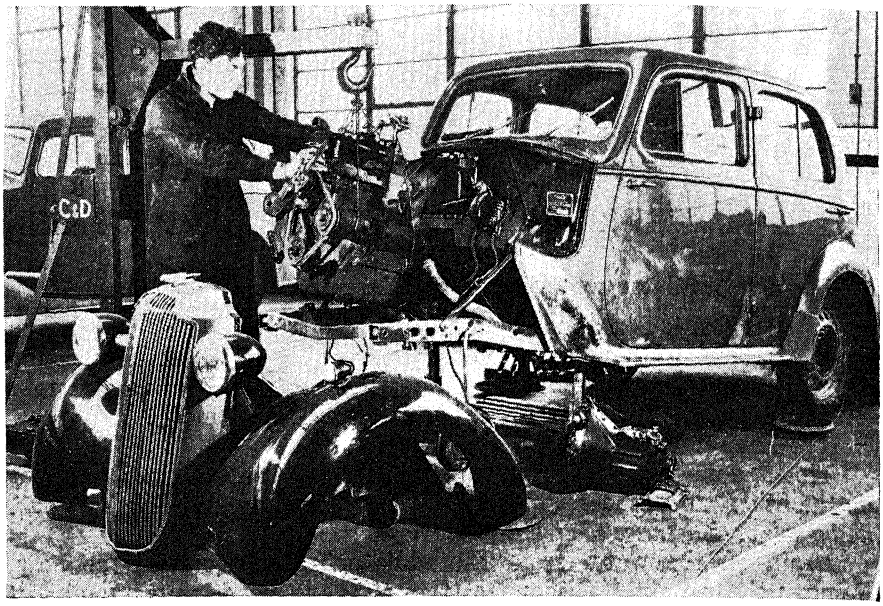


Fig. 2.—SHOWING EASY REMOVAL OF WINGS AND RADIATOR ASSEMBLY PRIOR TO DISMOUNTING ENGINE FROM SUB-FRAME (10 H.P.)

Remove the two screws which attach the wing valances to the frame side members; these screws pass through rubber insulated washers. Disconnect the wing stays at the point where they are attached to the inside of the frame. Remove the four bolts securing the front wings to the body on either side.

Remove the two bolts securing the front-wing and radiator-shell brackets to the front cross-member, taking careful note of the number of shims beneath each bracket.

Remove the screw at the front of the wings; this passes through a rubber insulated washer and secures the wing to the *inside* of the frame side member. The assembly can now be lifted away.

To replace, reverse the foregoing, ensuring that the same number of packing shims is fitted beneath the brackets.

To Remove Frame (Fourteen " J " model)

When it will be necessary to withdraw the frame on the Fourteen " J " model, in order to carry out repair work, this may be done by following the sequence of operations given below.

Remove the radiator and wings, engine and gearbox assembly, propeller shaft, and steering box.

Disconnect the main wiring harness, main petrol-feed pipe, and the

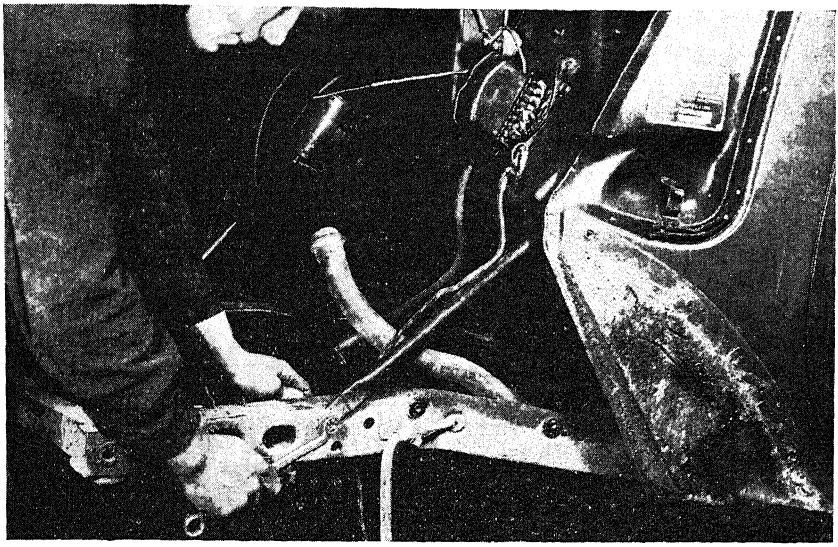


Fig. 3.—REMOVING SUB-FRAME ON THE VAUXHALL 10 OR 12 H.P.

Unscrewing bolt attaching diagonal body support to the sub-frame. Pull support sideways so that the spigot bush is drawn out of its hole.

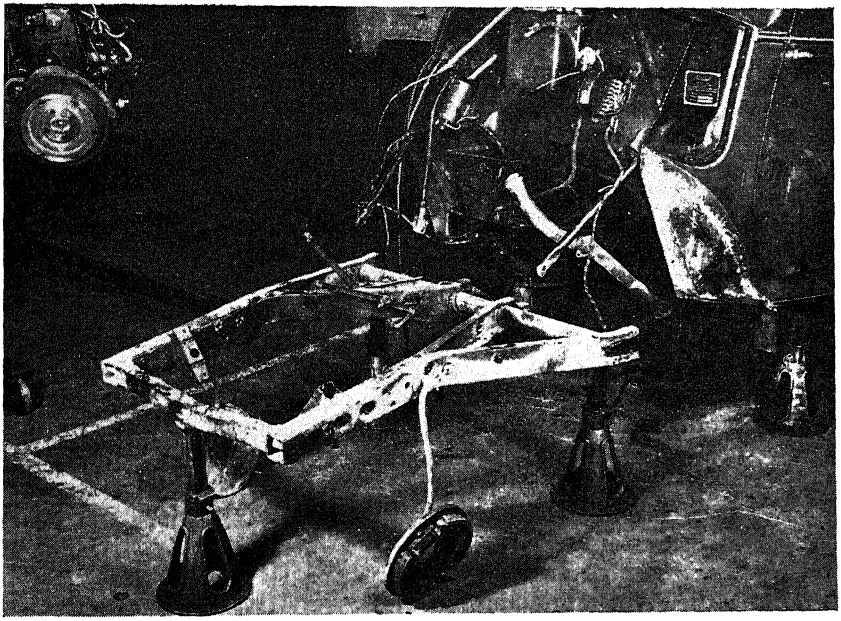


Fig. 4.—SHOWING SUB-FRAME DRAWN AWAY FROM THE BODY (10 H.P. AND 12 H.P.)

rear-brake feed pipe from the three-way connector on the rear axle and from the four-way connector on the rear cross-member of the frame.

Remove the pedal pads and stems from the pedal levers. Disconnect the speedometer cable from the clip on the frame, the handbrake front cable from the intermediate lever and from the bracket securing it to the frame, and the handbrake rear cables from the intermediate lever.

Remove the exhaust pipe and silencer assembly, and remove the two bolts securing the jacking brackets to either side of the frame and also the three setscrews attaching the brackets to the underside of the body; the brackets can now be lifted away.

Place supports beneath the front end of the body, then remove the ten bolts and setscrews which secure the frame to the body on either side. Remove the bolts attaching the two diagonal body supports to the frame and pull sideways, so that the spigot bushes are drawn out of their holes. The frame, complete with pedals, brake master cylinder and front-brake pipe lines, can now be drawn away from the body.

The Sub-frame on the Ten-Four and Twelve-Four

Removal of the sub-frame on the Ten-Four and Twelve-Four Vauxhall, which is secured to the forward end of the body below the scuttle by four bolts, two on either side, is carried out in similar fashion (*see* Figs. 3 and 4).

14-h.p. Independent Front Wheel Suspension

Disassembly of the front suspension simply for the purpose of checking is not recommended when universal front-end alignment equipment is available, as all checking operations can be carried out whilst assembled on the car with this equipment. For detailed notes on camber angle, pivot-pin inclination, caster angle, and toe-in, the reader is referred to the article in Vol. IV entitled "Diagnosing and Correcting Steering Faults."

Worn pivot pins or bushes, badly adjusted or worn wheel bearings, tend to give incorrect camber-angle readings, and therefore a true judgment as to the state of the front-suspension components—by which is meant the carrier arm and housing—cannot be obtained. Therefore, when an obviously completely worn assembly is noticed it is due for repair anyway, and should be proceeded with accordingly.

Alignment Angles

Toe-in	$\frac{3}{16}$ in.
Caster angle	7°–8°
Camber angle	0°–1°
Pivot-pin inclination	5°–6°
Included angle	5°–7°

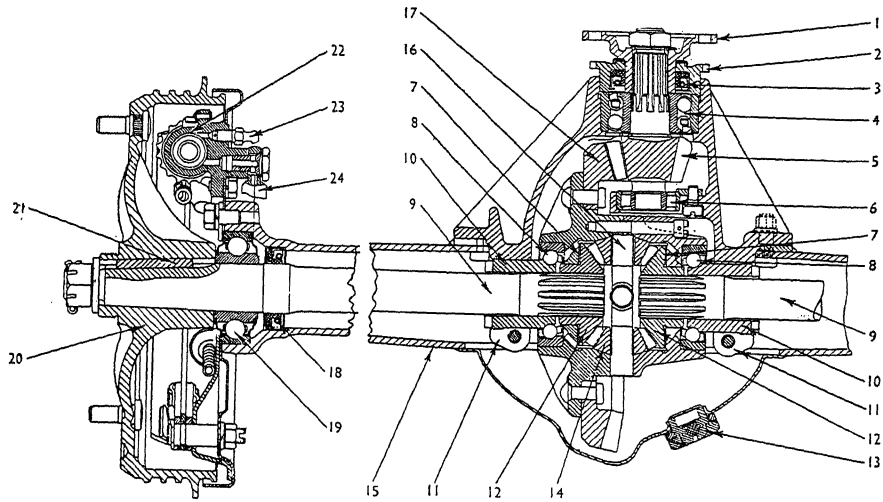


Fig. 5.—SECTIONED VIEW OF REAR AXLE

(1) Propeller-shaft Coupling Flange. (2) Pinion-adjustment Locking Ring. (3) Pinion Oil Seal. (4) Pinion Front Ball Race. (5) Spiral-drive Pinion. (6) Pinion Front-support Roller Race. (7) Differential Side Gear Thrust Washer. (8) Differential Ball Race. (9) Axle Shaft. (10) Differential Ball-adjusting Sleeve. (11) Differential-bearing Pedestal. (12) Differential Side Gear. (13) Axle-filler Plug. (14) Differential Pinion. (15) Axle Casing. (16) Differential-pinion Spider. (17) Spiral-drive Gear. (18) Axle-shaft Oil Seal. (19) Axle-shaft Bearing. (20) Rear Hub and Brake Drum. (21) Axle-shaft Key. (22) Brake-shoe Cylinder. (23) Brake-cylinder Bleeder Screw. (24) Brake Pipe-line. Connection.

Wheels and Tyres

Rim size . .	3–50 × 16 in.
Tyre size . .	5–50 × 16 in.
Tyre Pressures—Front	25 lb. per sq. in.
Rear	30 lb. per sq. in.

Incorrect Camber

If on checking it is found that the camber angle does not conform to the specifications, it will usually be found that the wheel carrier arm is bent and so needs replacement. Actually, this should not be decided upon until you have checked pivot-pin inclination.

Incorrect Pivot-pin Inclination

It is usual to consider the camber angle and pivot-pin inclination together, the addition of these two angles being termed the "included angle."

Now it will be seen that if, after making the checks on a car, the included angle is correct but that both camber angle and pivot-pin inclination are wrong, then the axle beam is bent or twisted.

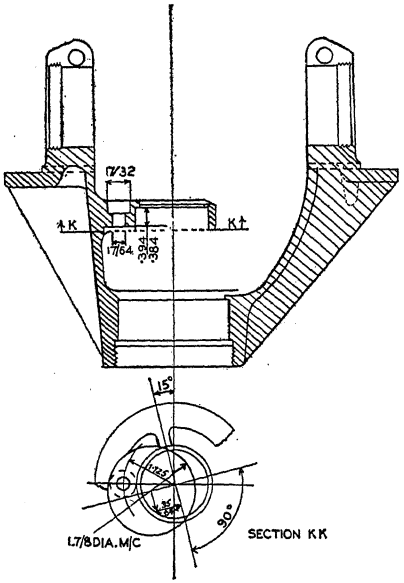


Fig. 6.—DIFFERENTIAL CASE-MACHINING INSTRUCTIONS

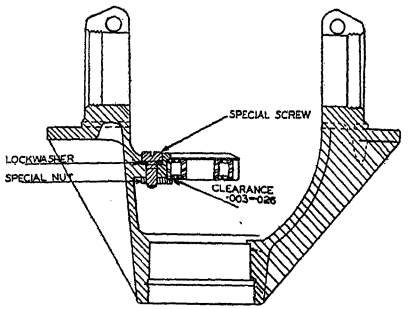


Fig. 7.—ASSEMBLY OF DIFFERENTIAL-PINION BEARING LOCATING NUT

If, however the pivot-pin inclination is correct and the camber angle wrong, then the wheel carrier arm is bent, the housing being of such stiff construction that it is practically impossible for it to distort.

Incorrect Caster

When the caster angle is found to be incorrect, either—

(*a*) the axle is twisted ;

(*b*) the axle is not attached correctly to the frame ; or

(*c*) the frame is bent.

When it is found that the caster angle is incorrect to the same extent on both sides of the car, it is usually a simple matter to correct by shimming the axle beam.

A description of the Vauxhall independent front-wheel suspension system is given on pp. 62–70.

Alignment Data for 10- and 12-h.p.

Caster, 7°–8°

Camber, 1°–2°.

Toe-in, $\frac{3}{16}$ in. (This is recommended for the 10-h.p. as well as the 12-h.p. model. Originally a parallel setting was recommended for the 10-h.p. car.)

Pivot-pin inclination, 4°–5°.

Pivot Pins

If excessive clearance is evident between the pivot pin and bushes or between the bushes and the knuckle bosses, the steering efficiency will be impaired and the bushes should be renewed. Production clearances

for all models are : pin clearance in bushes, ·0005–·0018 in., and clearance of bushes in knuckles, ·0001–·0018 in., and when renewing parts these limits should be observed.

Check the condition of the thrust-bearing and also the up-and-down float of the knuckle, inserting the necessary shims on the top face of the knuckle to provide a clearance of ·003 in. (·076 mm.) maximum. Shims of ·005 in. and ·010 in. thickness are available when correction is necessary.

REAR SUSPENSION

The rear axle of the Vauxhall 14 h.p. is shown in Fig. 5. Rear axles on the 10 h.p. and 12 h.p. are dealt with fully elsewhere. On 14-h.p. cars with Chassis No. J.5451 onwards, the outer race of the differential-pinion bearing is retained by a special nut and slotted-head bolt. Whenever an axle is dismantled for service work the opportunity should be taken to incorporate this method of location in accordance with the machining details given in Fig. 6. The assembly of the bolt and location nut is shown in Fig. 7. It will be observed that ·026/·003-in. (·66/·076-mm.) clearance is allowed between the face of the bearing outer race and the special nut.

To Reassemble Rear Axle (14 h.p.)

It is essential that the pinion adjustment shims are positioned correctly, so that they are nipped between the casing and the outer race of the ball bearing when the locking ring is tightened.

Make certain that both the locking ring and universal-joint flange nut are tightened securely, as otherwise a false adjustment may be obtained.

To Adjust

With the assembly held firmly in a vice the gears can be inspected for mesh. Adjustments should be made to obtain full-length engagement of teeth, smooth running, and a backlash between the spiral gear and pinion teeth of from ·005 in. to ·007 in.

Adjustment for this is obtained by slackening one spiral-drive-gear adjusting ring and tightening the opposite ring until the minimum amount of backlash can be felt.

When it is apparent that the spiral-drive pinion is too far in mesh or insufficiently meshed, it will be necessary to remove the pinion and remove or add shims. The shims available are of ·003-in. and ·005-in. thickness, consequently a close adjustment is possible.

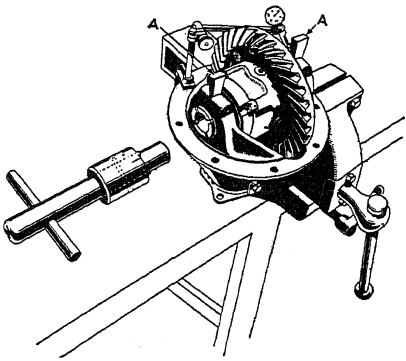


Fig. 8.—DIFFERENTIAL ASSEMBLY SET UP FOR PRELOADING BEARINGS

Note carefully that, although it has the appearance of an adjusting sleeve, no adjustment can be made by simply tightening or slackening the pinion locking ring: shims must be added or removed, and the pinion locking ring finally tightened prior to checking the new position obtained.

Carefully withdraw the pinion for the purpose of altering the number of shims, taking care not to damage the teeth.

Having satisfactorily completed the adjustment for backlash, that for tooth contact must be made.

It is absolutely essential to provide a load to the pinion shaft when rotating the gear. Without this it has been found that an adjustment can be obtained giving a marking which resembles correct contact, but which invariably results in a noisy axle when assembled. A sufficiently effective load can be obtained if a 4-in. diameter circular plate having rounded edges be turned and drilled for bolting up to the universal-joint coupling flange. This provides a comfortable grip for the hand. A brass plug with a $\frac{5}{16}$-in. S.A.E. thread should be screwed into the tapped drilling in the differential casing, so that the side and planet gears cannot rotate. In order to turn the spiral gear a handle should be made up and inserted to engage with the splines of one of the differential side gears.

For adjusting the teeth of the spiral-drive gears the reader is referred to the previous article, "Repair Notes on Vauxhall Cars," p. 169.

Preloading Differential Side Bearings

The final operation is that of preloading the differential side bearings to prevent deflection of the bearing pedestals under load, which would cause tooth-bearing variations. Preloading of the bearings became effective in production at Chassis No. JI.2435.

The extent of the bearing preload is 30°, and for accurate setting of the adjusting sleeves a special tool will be found necessary.

If the adjusting sleeves are excessively tight, taper wedges (*A*), Fig. 8, may be driven between the slots in the pedestals to ease the threads slightly.

Arrange a dial gauge to take deflection readings on the pedestal of the differential carrier on the spiral-drive gear side, as shown in Fig. 8. It is essential for the dial-gauge support to be clamped to the flange of the differential casing on the side opposite to the pedestal upon which deflection readings are taken, otherwise a true reading will not be obtained.

Now slowly tighten the left-hand sleeve (as viewed in Fig. 8) until movement of the pointer on the dial gauge indicates that the position has been reached at which the pedestals begin to deflect outwards. This is the point at which preloading begins, and must be carefully maintained during the next adjustment.

Slacken the left-hand differential-bearing adjusting sleeve (as viewed in Fig. 8) and tighten the opposite one *by exactly the same amount* until

the backlash between the spiral-drive gears has been reduced to ·001/·002 in. to allow for backlash increase during preloading.

Slacken the left-hand sleeve slightly and again determine the exact point at which preloading begins by noting the position at which the dial gauge begins to register deflection when the sleeve is tightened. Scribe a line on the left-arm carrier pedestal, as viewed in the illustration opposite one of the degree markings on the tool, taking up any slack between tool and sleeve before marking the pedestal. From this point tighten the same adjusting sleeve through a further 60° rotation, when the side bearings will be preloaded to the correct degree, and the backlash of ·005/·007 in. between the spiral-drive gear and pinion automatically restored.

Finally replace, and thoroughly tighten the clamp-bolts.

THE DAIMLER STRAIGHT EIGHT
(3½ LITRE)

By A. SQUILLARIO

Brakes

THE brakes are Girling mechanical type, vacuum-servo assisted, having a vacuum reservoir (*see* Fig. 1). A copper pipe (*D*) leads from the induction system to a non-return valve. From the non-return valve a pipe is led to the reservoir (*C*) and another pipe to the servo (*A*).

Removing Servo from Chassis

To remove servo from chassis, first disconnect pedal rod from brake pedal, and rear-brake rod from connection. Remove suction pipe and take care that joints are not damaged. Unbolt and remove servo from chassis. Note positions of bolts, etc., otherwise servo casing may be strained or distorted when bolted up to chassis.

Dismantling and inspecting Servo for Wear

Remove link-pivot pin and end cover, and withdraw piston assembly. Examine cylinder, piston, and all joints for wear. Thoroughly clean off all parts with paraffin, and dry carefully.

The piston leather should be carefully examined, and if not perfectly

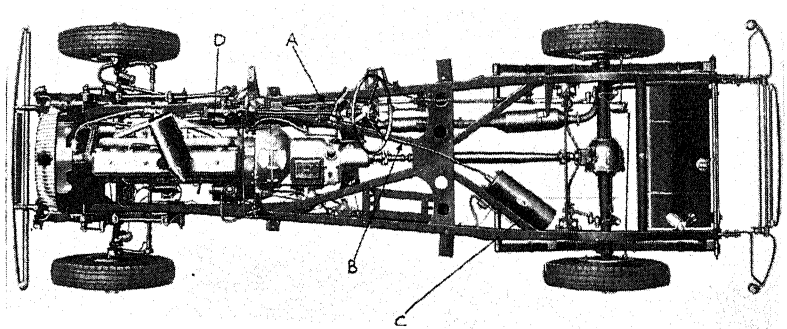


Fig. 1.—BRAKING SYSTEM

(*A*) Servo. (*B*) Pipe (reservoir to servo). (*C*) Reservoir. (*D*) Pipe (induction to non-return valve).

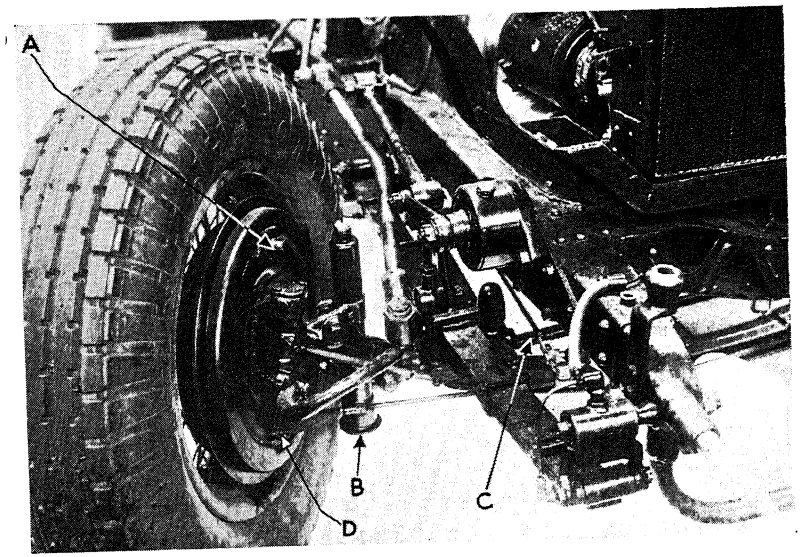


Fig. 2.—BRAKE ADJUSTMENT

(*A*) Brake adjuster nut. (*B*) Hydraulic jack. (*C*) Track rod. (*D*) Cone housing nuts.

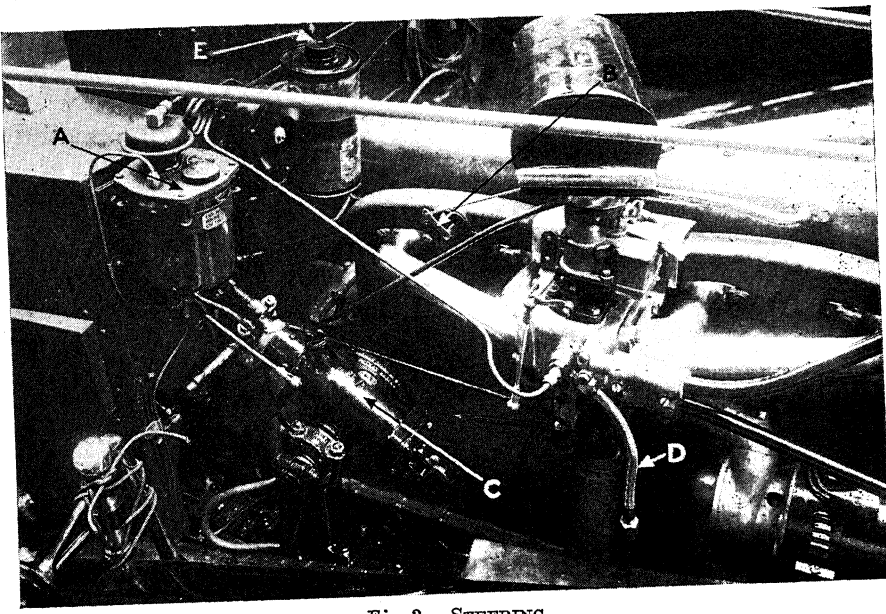


Fig. 3.—STEERING

(*A*) Oil container for automatic chassis lubricator. (*B*) Automatic choke control lever. (*C*) Burman-Douglas steering box. (*D*) Pipe to servo. (*E*) Hydraulic jack reservoir.

soft and pliable should be renewed. Inspect the hard brass expanding ring located underneath the leather. This should press the cup leather evenly on the walls of the cylinder. If it is not making even contact it may be slightly re-expanded. Although a fairly large working clearance is allowed on the piston, the cup leather must make good contact all round the bore to prevent leak.

Refitting Servo to Chassis

As stated previously, great care must be taken to see that the servo is not strained when refitted to the chassis. Before coupling up servo to brake pedal and brakes, see that both of these work quite freely and are well lubricated. A tight brake pedal will cause sluggish release of the servo as well as absorb braking effort.

After fixing servo to chassis, the rod coupling servo to brake pedal should be fixed, and great care must be taken to see that the levers in the servo are back in their rearmost position, *and the pedal is in its fully "off" position.*

This is of paramount importance, for the total travel of the servo should coincide with the total travel of the brake pedal. This point should be checked very carefully before the brake rod from the servo to the brake cross-shaft is attached.

The length of the rod between servo and brake pedal is of extreme importance, and once determined should never require alteration. *All adjustments must be made behind the servo.*

In refitting the suction pipe, see that a good leak-proof joint is obtained. With the exception of a few drops of oil in plug hole on top of servo, no other attention is required.

Adjusting Brakes

Adjustment of brakes is very simple. Tighten adjuster nut (*A*) (Fig. 2) as far as possible, slacken nut back a quarter of a turn (a click will be heard), and brake is then adjusted correctly. Repeat on each wheel.

Warning.—Do not tighten up the split cone housing nuts (*D*), as it is intended that the housing should be allowed to float to a limited extent.

Steering

Occasionally reports are received of erratic steering, commonly called "wobble." In most cases this has been a matter only of adjustment. All adjustments to the steering should be entrusted to a competent mechanic. Burman-Douglas steering is fitted.

Wheel Alignment

The toe-in should be from $\frac{1}{8}$ in. to $\frac{3}{16}$ in. These figures are absolute minimum and maximum respectively. These measurements should be

taken from the edge of the rim at wheel centre. To adjust, slacken locknuts at both ends of the track rod, and rotate track rod until correct adjustment is obtained, and tighten locknuts (*see* Fig. 3).

Caster angle should be 2°, and should not exceed 2½°. Offside and nearside should be checked, as a variation may exist between the two.

Special equipment is obtainable for accurately checking the caster angle, but if not available the following method may be used :

The angle can be measured by an inclinometer off the top of the swivel-pin bush. This must be done very carefully, as the actual surface available is so small, and a false reading may be obtained.

It is important that the wheel nuts are kept tight. A copper hammer is supplied in the tool-kit, and this should be used in conjunction with the wheel spanner to ensure that the nuts are *really* tight.

THE THORNYCROFT STURDY CHASSIS

CHASSIS TYPE ZE 5-TON (forward control)
YE 5-TON (normal control)

REAR AXLE

THE rear axle is of the fully floating overhead worm type, and transmits the driving thrust to the frame through the road springs. The rear spring clamping bolts must be kept screwed up tight, and it is advisable to examine them from time to time, more particularly during their early life, to make sure they are tight. The level of the oil in the axle casing should be verified occasionally, and brought up to the top of the filler plug. We advise users to clean out the casing, using a mineral flushing oil, and to refill with fresh oil every twenty thousand miles, or more often if convenient. A good quality gear oil is essential, about 1 gallon being required to fill to correct level. *Grease must on no account be used in the rear axle.*

Dealing with Oil Leakage along Axle Shaft

Oil leakage along the axle shafts is prevented by a spiral oil seal at the inner end of each axle sleeve. These are secured by a screwed dowel, which can be removed with a screwdriver when the worm-gear casing is lifted off. A gland, packed with impregnated felt, is fitted at the front end of the worm-shaft, but should oil leakage develop here the gland should be tightened just enough to prevent further leakage. Whenever an oil leak has been found, make sure that the oil in the axle casing is up to the correct level.

Parallel roller bearings are fitted to the rear-wheel hubs, and as these require no adjustment, little attention is needed other than lubrication. Should excessive play develop in the hub, it will be found that the bearings are worn, and a new set will have to be fitted.

The hubs should not be over-lubricated, otherwise the excess grease will be thrown on the brake drums.

Dismantling Rear Axle

When dismantling the rear axle, the worm-gear assembly, with differential, can be lifted complete with top cover, after the propeller shaft is uncoupled and the differential shafts are withdrawn. These need be

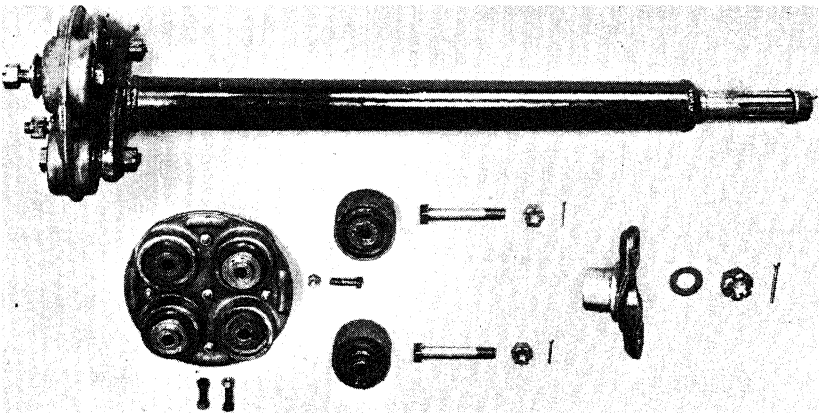


Fig. 1.—ASSEMBLY AND PARTS OF " YE " AND " ZE " PROPELLER SHAFT AND UNIVERSAL JOINTS

drawn out only about 6 in., and if the driving flanges stick when the eight bolts securing them have been removed, insert setscrews into the two tapped holes in the flange, and screw up evenly until the flange is parted from the hub. If the hubs are to be removed, first take off the hub cap and withdraw the differential shafts completely. Next take out the small bolt which locks the hub nut, and screw this nut off the axle sleeve. The hub and bearing assembly can then be withdrawn complete. When dismantling the hub, the oil retainer on the inner end must be removed before the bearing at that end can be withdrawn.

Gear-oil Specification

For the rear axle a good quality amber gear oil of medium thickness is preferable. Do not use a thick black oil.

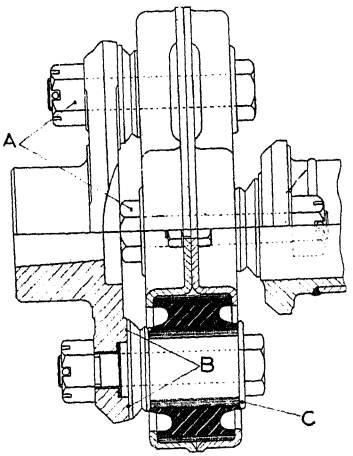
A suitable oil should have the following characteristics :

Viscosity at 140° F.	400–700 seconds.
Cold test	Not above 30° F.

This specification is approximately equivalent to S.A.E.140.

PROPELLER SHAFT

The drive is transmitted by a two-part tubular propeller shaft, which is supported at the rear end of the forward part by a roller bearing attached to one of the frame cross-members. The intermediate bearing should be lubricated with gear oil, the oil-gun nipple being located on the grease-nipple plate on the left-side frame member.



2.—PROPELLER SHAFT UNIVERSAL JOINT

Removing Intermediate Shaft

To remove the intermediate shaft, disconnect the oil pipe to the bearing housing, and take out the coupling bolts at each end. Undo the two bolts holding the intermediate-bearing support plate to the frame cross-member, and remove the shaft complete with bearing and bracket. Do not let the rear shaft hang down when the front end has been disconnected, or the rear coupling may be strained.

To Remove Intermediate Bearing

To remove the intermediate bearing, draw off the universal-coupling fork and take out the bolts fastening the bearing housing to the support bracket. The two halves of the bearing housing may then be parted. Take away the support bracket and draw the bearing off the shaft. The oil seals in the bearing housing should be renewed if worn, and the cork joint for each half-housing should be replaced if broken.

Check Universal-joint Bolts for Tightness

The coupling bolts (*A*) (*see* Fig. 2) should be checked for tightness occasionally. These bolts are made of specially tough high-grade material and will stand more than normal tightening. Use an extended length of spanner, if necessary, to bring the split hole in line with the slots in the nut.

If the bolts are not correctly tightened, the sleeves will rock, destroying the flat abutment faces (*B*), and no amount of subsequent tightening will rectify this.

If the couplings should be dismantled at any time, or in the event of new couplings being fitted, see that the washer (*C*) is assembled in the position shown, and not under the nut behind the companion flange.

Lubrication

All the brake-rod joints must be kept free and well lubricated, also the cross-shaft bushes. The pins of the joints must be oiled with an oil-can, but the cross-shaft bushes are fed from an oil-gun nipple on the grease-nipple plate attached to the left-side frame member. Take care not to over-lubricate the brake camshafts or hubs, as the excess oil may get on to the brake drums and adversely affect their stopping power.

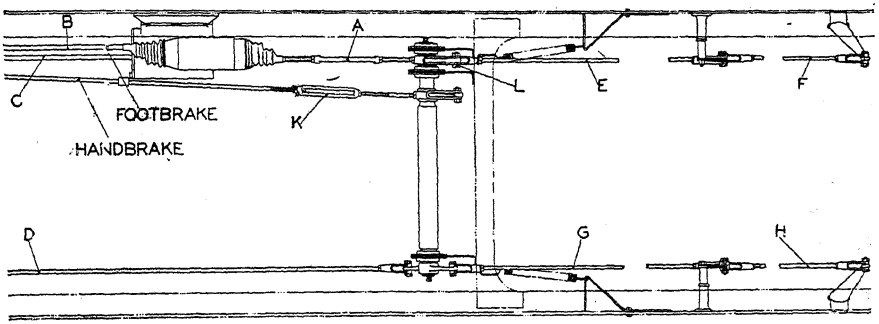


Fig. 3.—ADJUSTMENT OF BRAKES

When Relining Shoes

When all the adjustment on the brake lining has been taken up and it is necessary to reline the brake shoes, countersink the rivet holes deep into the brake-liner fabric, so that the head of the rivet is well below the surface of the fabric when fixed to the shoe. After riveting, file the brake liner to remove the burrs. The brake drums are mounted on the outside of the hub flange and retained by spherical seatings, so it is not necessary to disturb the hub bearings when removing the brake drum.

Greasy Brakes

If grease or oil has found its way into the brakes, this should be cleaned off with petrol. Greasy brakes generally indicate over-lubrication of the hub bearings, and to prevent this the quantity of lubricant injected into the hubs and brake camshafts must be reduced.

Adjustment of Brakes

As the hand-brake operates the same shoes as the foot-brake, it must be remembered that adjustment will be required, even when this brake is seldom used, owing to the wear caused by constant use of the foot-brake; and because of this it is the hand-brake which should be watched to determine when it is necessary to adjust the brakes.

Normal Adjustment

The foot-brake is assisted by a vacuum-servo cylinder, and operates on both front and rear axles. The leverage has been carefully arranged to give the maximum braking efficiency, and a quick adjustment of the brakes is provided by the turnbuckles (*A*) and (*K*) (*see* Fig. 3), and all adjustments for normal wear of the linings must be made here. Before the brakes have worn sufficiently to let the hand-lever up to the end of its travel, it will be necessary to adjust them. The hand-brake operates on all four wheels, and is connected to the same set of shoes as the foot-brake.

Rods (*B*), (*C*), (*D*), (*E*), (*F*), (*G*), and (*H*) (Fig. 3) are set to the correct length before leaving the manufacturers, and must not be altered except in exceptional circumstances.

To Rebalance Brakes

To rebalance, should this become necessary, put the hand-brake in the "off" position, pack the brake pedal down about 3 in., and adjust the turnbuckle (*A*) (Fig. 3) until the nearside rear-wheel brake is beginning to grip, giving the hand-brake turnbuckle (*K*) one and a quarter times the number of turns given to (*A*). Check off the offside brake, and, if necessary, shorten or lengthen the rod (*E*) until the drag on the offside wheel, when rotated by hand, is the same as that on the nearside wheel. To adjust rod (*E*), slacken off the locknut on the brake rod, withdraw joint pin (*L*), and turn the brake-rod jaw in the required direction. The front-wheel brakes should be balanced at the same time by slackening off the locknut on the front-brake rod and adjusting the jaw at either wheel.

Test for Unequal Temperatures of Driving

When next on the road after having made the above adjustments, test the brakes for balance, after a few applications of the foot-brake the temperature of the rear-wheel drums should be equal and the same applies to the front. Should this not be so, the cause may be due to oil or grease having found its way into one of the drums, and if this is the case the drums and linings must be thoroughly cleaned before retesting. If the rear-wheel drum is affected, the oil chute for draining away any excess lubricant from the hub should be examined to see that it is not clogged up, and less grease should be injected when subsequently lubricating the hub.

As the adjustment of the turnbuckles is taken up, examine the pull-off spring attached to the brake cross-shaft, and if the tension of the spring is increased unduly, move the spring-anchor bracket forward to the next hole.

Squeaking Brakes

Squeaking brakes are nearly always caused by uneven adjustment of the brakes. When the vehicle is jacked up off the ground, the brakes, when applied, should press evenly on all brake drums. If this is not the case, then they should be adjusted by the procedure indicated in previous paragraphs.

FRONT AXLE

The axle body is of I-section, and is forged in one piece. The stub-axle swivel pins are supported on tapered roller bearings, and an aluminium cover is fitted to prevent the intrusion of dirt and water.

The nuts on the spring holding-down bolts must be kept screwed up tight, and should be checked occasionally for any sign of slackness.

Little attention to the front-hub bearings will be needed beyond regular lubrication, as these are of the parallel-roller type, which do not require adjustment.

Worn Hub Bearings

If, after considerable use, excessive play should develop in the hubs, it will be found that the bearings are worn, and a new set will cure the trouble. To remove the hub, it is only necessary to take off the hub cap and unscrew the nut on the end of the stub axle. The hub and bearing assembly can then be withdrawn.

The lubrication of the hubs should be inspected at regular intervals, but they should not be over-lubricated, otherwise the excess grease will be thrown on to the brake drums.

Wheel Alignment

The alignment of the front wheels should be checked occasionally, particularly after any collision, or if the tyres are wearing badly. About $\frac{1}{8}$-in. toe-in should be given, measured at the centre-line of the wheel, the ends of the track rod being screwed right hand and left hand to facilitate this adjustment. After the adjustment has been made, be sure to tighten up the clamping bolt on both track-rod sockets, or damage to the adjusting thread will result if the sockets are allowed to run in a slack condition.

VACUUM SERVO

The vacuum servo is of the pedal type, controlled by a hinged pad on the pedal. A certain amount of care and attention is needed if the maximum of efficiency is to be obtained.

Testing Servo Operation

If the servo is suspected of being faulty, it can be tested by either of the following methods :

(*a*) Press brake pedal hard with engine stationary, and while still pressing start up engine. Immediately the effect of the servo will, or should, be felt, by a considerable reduction of the manual effort on the pedal. In this way the degree of assistance given by the servo can be judged.

(*b*) While still pressing on pedal switch off engine, when the loss of vacuum should produce a very noticeable reaction on the pedal.

If these two tests prove the servo to be working, but braking is still poor, the next thing to suspect is a leak in the pipe line, which may be traced by pouring oil from an oil-can over the pipe joints while the engine is running. If there is a leak the oil will be sucked in and slowly disappear.

In any case the leak has to be fairly considerable to have any material

effect on the power of the servo ; this may sound somewhat surprising, but it must be remembered that the engine is acting as a huge vacuum pump making vacuum far quicker than can be used by the servo.

Dismantling and Cleaning Servo

To remove the servo from the chassis, first disconnect the pedal rod from brake pedal, and the rear-brake rod from its connection to cross-shaft. Remove suction and oil pipes, taking care not to lose the special washers used for making the joints. Unbolt and remove servo from chassis, taking note if any packing or washers have been used in the fitting. If so, these should be carefully noted before refixing, otherwise, if any are misplaced, the servo casing may be strained or distorted when again bolted up to the chassis.

When dismantling, first of all remove the top cover and the cylinder end cover. Then, after disconnecting the lever axle, operating rod, and levers, the piston, complete with spring, chain, and lever mechanism, can be withdrawn through the cylinder bore.

Examine the cylinder, piston, and all joints for wear, and thoroughly clean with paraffin ; the piston leather should be carefully examined, and, if not perfectly soft and pliable, should be renewed. Under this leather is a hard-brass expanding ring, and this too should be inspected and, if necessary, slightly re-expanded so as to ensure its pressing the cup leather to make even contact on the walls of the cylinder. A fairly large working clearance is purposely allowed, but this cup leather must, of course, make good contact all round the bore to prevent leak.

The whole of the lever assembly should be carefully examined, and if any undue wear has taken place in any of the joints these should be rebushed or renewed.

When reassembling the servo all screws and nuts should be tightened up evenly, each a little at a time, particularly those on the cylinder end cover.

Great care must be taken to see that the servo is not strained when rebolted to the chassis.

Before coupling up the servo to brake pedal and brake cross-shaft, see that both of these work quite freely, and are well lubricated. A tight brake pedal will cause sluggish release of the servo, besides absorbing braking effort.

The rod coupling the servo to brake pedal should now be fixed, and great care taken to see that the levers in the servo are back in their rear-most position and the pedal in its fully " off " position. This is of the utmost importance, for the total travel of the servo must always coincide with the total travel of the brake pedal. This point should be very carefully checked before the brake rod from servo to brake cross-shaft is attached.

The length of the rod between the servo and brake pedal is of extreme

importance, and once determined should never require alteration, and on no account should any adjustment be made to the original setting. All adjustments must be made behind the servo.

Lubrication is provided by means of an oil-cup. This ensures that the servo gets the required lubrication if the oil-cup is filled with medium gear oil about every five hundred miles.

It is important that the rubber or leather gaiters on the servo are kept intact and well fitting. If allowed to become detached, or loose fitting, dirt and water are likely to get inside the mechanism and set up undue wear, and affect its efficiency.

STEERING GEAR

The steering gear is of the cam-and-lever type, giving the vehicle a turning circle of approximately 52 ft.

Adjustment for End Play

The adjustment for end play of the hardened steel cam is affected by a series of shims located between the end cap and the face of the steering box. Remove one or more of these shims, as required, until end play disappears, care being taken to see that when the end cap is securely rebolted, the thrust-bearings are still free to rotate. Care should be taken to see that the joint between the end cap and the box is properly remade if oil leakage is to be avoided. The gear should be filled up with oil to replace any loss during adjustment.

Adjustment for Play between follower and track

Adjustment for play between the follower and track is effected by renewal of the hemispheres, those on one or both sides of the follower being changed according to the degree of adjustment required. Remove the cover plate, and drain off sufficient oil to expose the cam and its track.

Withdraw the follower from its bronze bearing in the rocker shaft.

Replace one pair of hemispheres from one side of the follower by a new set, and insert the follower unit into the cam track in its mid-position, i.e. approximately midway between the two ends of the cam. This, for the moment, should be done independently of the rocker shaft, which should be moved over to one side to leave the centre portion of the cam track exposed.

Should further adjustment be required, the remaining set of hemispheres should be replaced in like manner.

Correctly adjusted, the follower unit should be a free sliding fit in the centre portion of the track, to ensure a free passage of oil between the surfaces, but only a minimum of side play should be permitted. Too close a fit will result in a stiff steering. This point determined, it now remains only to replace the follower unit through the rocker shaft and

into the track. This is most easily done with the rocker shaft over in the extreme lock position, as the track is purposely made slightly wider at these points. A little care should be exercised here, and the hemispheres may with advantage be slightly tilted in their seatings to give a lead-in effect when entering the track. A slight to-and-fro movement of the steering wheel in conjunction with a light pressure on the back of the follower facilitates this assembly.

When inserting a new set of hemispheres, see that they are quite clean and free from grit before inserting into the follower. A smear of thick grease in the seatings will check any tendency for them to fall out.

The cover plate and its shims should next be replaced, taking care to remake the oil joint properly, and the gear filled up with fresh oil.

The shims between the cover plate and the box should not be removed. They are intended for initial assembly only. A certain amount of end play is called for, and is desirable in the rocker shaft, and no attempt should be made to take this up by removing these shims.

Should the thrust-bearings be, for any reason, taken off the shaft, care should be taken to replace them the right way round. The right way round is when the word " thrust " stamped on one side of the inner race of the bearing is up against the end of the cam.

Refitting Drop-arm to Rocker Shaft

Should it be necessary to remove the drop-arm from the rocker shaft at any time, before doing this both these items should be marked, so that they can be fitted together again afterwards in the same relative positions.

In case this marking has been omitted or in case the marking has become obliterated, the following is the correct method of fixing this, and special attention should be given to this matter. Should this operation not be carried out properly, almost certainly the available lock will be limited in one direction or the other, and damage may result to the internal mechanism of the gear.

The steering column complete with steering box, but without the drop-arm attached, should first be fitted in place in the vehicle, taking care to tighten up all fixings holding the unit to the chassis, including that on the dashboard, the steering wheel being placed on its final position. Next, the lower end of the drop-arm carrying the ball pin should be fixed correctly to the drag-link, but the top end should not yet be connected to the rocker shaft of the steering box.

Now jack up the front wheels and place them approximately in the straight-ahead position.

If, now, the steering wheel is rotated gently, you will find that its movement is limited by internal stops in the steering box at each end of the travel of the internal mechanism of the gear. The number of turns of the steering wheel required to bring the gear from one end of its travel to the other should be counted. Then, commencing from one of these stops,

take the wheel back half the complete number of turns available, which will bring the steering mechanism into its central position.

Now, with the gear mechanism in this, its central position, as explained above, the front wheels set pointing slightly as though the vehicle were turning a right-hand corner, fit the serrated cone in the top of the drop-arm on to the rocker shaft. The reason the front wheels are set in this position is because in the ordinary fore-and-aft system of steering, the steering wheel has always to be moved through a greater angle when going from straight ahead to full right lock than when going from straight ahead to full left lock.

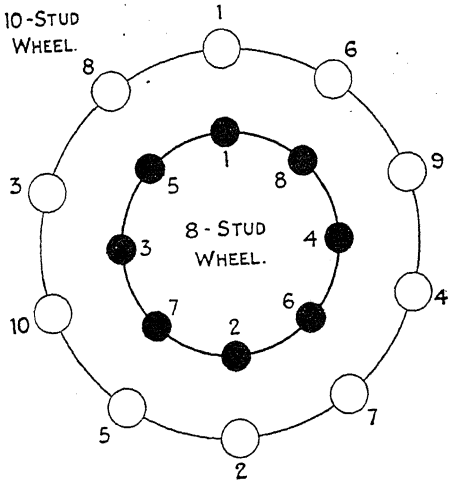


Fig. 4.—FITTING DISC WHEELS

Before tightening up, the following check should always be carried out.

The front wheels still being jacked up, with the steering wheel pull the steering right over to lock, either right or left. With the steering wheel and front wheels in this position, drop the drag-link off the drop-arm, and see whether you can move the steering wheel any farther in this same direction. If you can, everything is in order, and the same procedure should then be followed on the other lock.

Adjusting Front-axle Stops

Should further movement of the steering wheel be unobtainable, it means the front-axle stops are not operating, and some adjustment must be made, as follows:

If there is movement of the steering wheel available on one lock, but not on the other, the drop-arm should be put on the next serration on the rocker shaft, which may put matters right. If no serration will give free movement of the steering wheel at both locks, then the front-axle stops must be looked to, and altered, so that there is. The amount of free movement available after dropping the drag-link of the drop-arm should be the same at both locks, and this condition is what should be aimed at.

It will be appreciated that the movement of the rocker shaft and drop-arm is restricted by the internal stops fitted in the steering box, and it is therefore necessary to fix the drop-arm and connect the same up to the front wheels on the one hand, and to the steering-box mechanism on the other hand, so that the necessary movement of the front wheels from lock to lock is obtained at the same time as the follower is travelling from end

to end of the cam track, but not far enough in either direction to hit the internal stops in the steering box.

A large-size oil plug is provided at the top of the steering-box casting, and this box should be kept full of a medium gear oil.

Once the gear is full of oil, however, no attention should be necessary except periodically, say once in three months, to make up the full quantity of oil through this filler.

The design of the gear is such that the oil thus applied reaches every part of the gear.

A drop or two of castor oil now and again on the rubber and carbon bush at the top end of the steering-wheel spindle may be given, if necessary. Grease must not be used.

WHEELS AND TYRES

Disc wheels, having counterbored bolt holes, are carried solely on the plain cone or spherical faces of the studs and nuts.

They are not supported by the studs proper or by the spigot on the hub. The diameter of the bore of the wheel is slightly larger than that of the spigot, and there is always ample clearance for the studs in the stud holes.

Replacing Wheel

When replacing a wheel, screw up all the nuts until they just begin to grip, and then tighten them a little at a time in the order shown in Fig. 4 until fully home. This should be performed while the wheel is jacked up clear of the ground. The object is to enable the wheels gradually to seat themselves evenly on the faces of the studs and nuts ; the seating portion of the nut will then take up its correct position in the wheel.

It is specially important to observe this procedure when mounting twin wheels. It is extremely bad practice to screw one nut fully tight before moving to the others. When the vehicle is first put into service, or when a new wheel has been fitted, the wheel nuts are liable to work loose, so these should be tightened up daily to commence with, gradually extending the operation to a weekly period. After the wheels and nuts have " bedded down," a fortnightly inspection should be sufficient.

See that no rust tends to form on the studs or nuts if the wheels have not to be changed for a long period.

If there is a likelihood of this, due to exposure to mud or moisture, it is advisable to remove one nut at a time completely from its stud, smear the threads with gear oil or grease and replace it, or alternatively jack up each wheel, completely remove it, and attend to all studs and nuts.

Care of Tyres

Careful and regular attention must be given to the tyres if maximum service is to be obtained from them and maintenance costs are to be kept low.

Inflate the tyre to its correct pressure and check the pressure frequently with a pressure gauge and make up any loss ; running with slack tyres is injurious to the tyres themselves. Avoid fierce braking, if possible, as this increases tyre wear considerably.

If either of the rear wheels has to be changed, the spare should be as nearly as possible the same diameter as the tyre on the other side of the vehicle. If one is of larger diameter than the other, as in the case of a very worn tread compared with a new tread, the differential gear in the axle will be called upon to do more work than is intended. This, however, may be unavoidable at times, but the wheel should be changed at the first opportunity.

If twin-tyre equipment is fitted, and a new or different make of tyre is fitted to one wheel of a pair, it may be called on to carry an undue proportion of the load. This should be checked when fitted and is best done on a flat, smooth section of ground. Tyres should be matched as much as possible ; a slightly larger tyre of a pair should preferably be fitted to the outside, to be accommodated by road camber.

Road Springs

Long semi-elliptic springs are secured to the axles by our patent spring-fixing device, which allows freedom of action of the springs, and at the same time relieves the holding-down bolts of heavy stresses. It is however, as well to examine the bolts from time to time, particularly during the early life of the vehicle, to see that they do not work slack, as the springs also transmit the driving and braking thrust from the axles to the frame. Inspect the shackle bolts at the same time, and tighten if necessary.

As a general rule, in the case of spring breakage, only one leaf will be found to be broken, and the remaining leaves can be utilised to build up a new spring when a replacement leaf is obtained ; but it must be remembered that the severe strain which broke the one leaf must have been sustained by the other leaves, and they should be examined carefully for some time afterwards in view of other possible breakages.

When overhauling the vehicle, the springs should be removed so that the bushes and pins may be examined and the leaves dismantled and washed with paraffin, but before being reassembled they should be well greased all over with a mixture of graphite and grease.

Fuel System

The fuel tank is mounted on the side of the chassis frame, where it is easily accessible, the fuel feed being affected by an Autovac fitted to the dash. On the bottom of the tank a sump with drain plug enables the tank to be drained and flushed out. A glass-type fuel filter is fixed on the frame just in front of the tank, and periodically the bowl of the

filter should be taken off, and any foreign matter which has collected be washed out.

The filter consists of a series of corrugated plates mounted on a centre tube and held together by a knurled nut at the bottom of the centre tube. The corrugations are sufficiently small to allow only petrol to pass between these thin plates, so that foreign matter is trapped at the outside edges of the plates. The vibration of the vehicle as it travels should shake off this collection from the plates on to the bottom of the bowl, but it is also advisable to occasionally remove the bowl, slacken the bottom knurled nut, and spin the thin plates round to cast off any collected dirt. This is best done with the fingers, not with a cloth, which may leave fluff on the edges of the plates. Then tighten the knurled nut up with the fingers and thumb only. Too tight a nut tends to crush the corrugations out of the plates and stop even petrol from passing between them. The nut is captive on the centre tube, so that even if not tight enough the worst that can possibly happen is for it to work slack and allow dirt to pass between the loosened plates; they cannot come off. The fuel tap is underneath the Autovac in the feed pipe from the Autovac.

The Autovac requires little attention beyond draining out any sediment through the cock in the bottom about once a week, and cleaning the filter in the fuel-pipe connection at the top every month. See that the screws holding the top cover are tight, to ensure an air-tight joint.

The fuel tank has a capacity of 15 gallons.

Grease Specification

The grease used on the vehicle must be a smooth, well-manufactured product, made from a high-grade calcium soap and a highly refined, well-filtered, mineral oil of medium viscosity. It must conform to the following tests:

Consistency	Soft.
Ash	2·30 per cent. max. (as Ca°).
Moisture	1·00 per cent. max.
Resistance to water	It must not readily emulsify with water.
Melting-point	Not below 195° F. (*Ubbelohde*).

and be free from corrosive matter, grit, or fillers of any kind.